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SÁNDOR KOCH

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GYULA GRASSELLY

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Acta Miner. Petr. Szeged

MICROSTRATIGRAPHY OF THE CARBONATE MANGANESE ORE LAYERS OF THE SHAFT III. OF ÚRKÚT ON THE BASIS OF PALYNOLOGICAL INVESTIGATIONS

M. KEDVES and P. SIMONCSICS

Institute for Botany of the József Attila University, Szeged

INTRODUCTION

The first data about the pollens of the manganese ore of Úrkút were published by the authors previously (1961). In this work it was established, that the manganese ore as a sediment may contain sporomorphs, although the monstly oxy-ores are rather unsuitable for quantitative palynological evaluation. In the 47 samples first investigated only two samples were found suitable for quantitative evaluation and even these samples were argilliferous. Authors' attention was therefore turned to the carbonate ores when they prepared the diagram of the fundamental profil which is indispensable for the more detailed investigations with palynological methods. From the primary manganese ores of Úrkút, known from the work of CSEH—NÉMET (1958), the mother-lode of manganese ore of the shaft III. was investigated by the authors with positive results. All samples contained microresidues in a quantity which was sufficient for quantitative evaluation. In the followings this profil will be considered as a fundamental profil. Microscopical investigations results in a very rich material of spores, pollens and microplancton. The abundance of forms considerable surpasses the coenosis published in authors' previous work. Several new taxa, form-species, form-genera were described and also taxa of higher orders were initiated. These results are published here only fragmentary due to the limited space. The problems connected with the palynological microstratigraphy of the profil of the carbonate mother-lode will be discussed in detail.

MATERIAL AND METHODS

The profil of the manganese ores of the mother-lode of the shaft III. of Úrkút was investigated in full. Figure 1. shows adjoining the drawing of the fundamental profil the exact depth of the samples and the quantitative palynological data. In consequence of the continuity of sampling in the representation of the quantitative data the values were halved and were plotted in that way on the two sides of a central axis. The sequence of the taxonomically heterogenous sporomorpha-groups, drawn together in different grade, was determined according to the stratigraphical significance.

Method of the preparation of the material for microscopical investigations was the following:

About 100 g of the ore was breaked into little fragments in a porcelain mortar. The fragments between 0,5 and 0,25 mm were separated with the aid of sieving and 20 g from this fraction were measured in a beaker. Digestion was began with diluted hydrochloric acid till the sample became plastic. This require generally 5-10 hours or sometimes 3-4 days. The remaining acid and salts were decanted and washed out with distilled water. Thereafter the organic constituents separated from the minerals with the aid of $ZnCl_2$ (ZÓLYOMI, 1952). The $ZnCl_2$ was washed out with distilled water. This washing must be performed with the greatest care; the quality of the preparates depends highly on this operation! The anorganic matter still remaining was removed with hydrofluoric acid. After washing, the material is suitable for microscopical examination, although the sporomorphs are extremly dark and the fine structures are not or only hardly to see. For clarifying of the spores and pollens salpetre acid and potassium hydroxide were used. Naturally, a very careful washing was performed after each of these treatments too. The centrifuged material was transferred in vials with glycerol-gelatinate containing glycerol. For the microscopie investigations glycerol-gelatinate preparates were made and 60× and 90× homogeneous immersion objectives were used. The photomicrographs were made with the same objectives and are published here unretouched.

NOMENCLATURE

Nomenclature of mesozoic sporomorphs is only a little elaborated as compared to that of the terciary ones. Present investigations of the authors made possible a more profound discussion of the spores and pollens of the Jurassic period. In connection with the nomenclature the heterogenous character of the trends must be emphasized. The most important trends are reviewed in the followings:

1. ERDTMAN (1948) used in the description of *Tricolpites (Eucommiidites) Troedssonii* ERDTMAN 1948 the trinomial nomenclature initiated by himself *(nomen typicum abstractum; nomen typicum concretum; nomen differentiale).*

2. REISSINGER (1950) in his work made an effort to range the sporomorphs demonstrated by him among natural categories, e. g. he used the following designations: *„Meist Palmen-Pollen; Vielleicht cf. Larix; Podocarpaceen-Pollen; Equisetaceensporen; Vermutlich Taxodiaceenpollen; cf. Lycopodium inundatum; cf. Selaginella selaginelloides* LINK" etc. In the case, when the exact determination met with difficulties, he used names of general characteristic (e. g. *„vermutlich Farnspore")*, or artificial names: e. g. *Pityosporites pallidus* REISS. 1938 (=*Pityopollenites pallidus* REISSINGER 1950), *cf. Pollenites hiatus* R. POT., *Sporonites neddeni* R. POT. Also ROGALSKA (1954) follows this trend, she made efforts for identifications with recent taxa.

3. KARA—MURZA (1960) combines in his book three trends; he uses natural, semi-natural and artificial names. Examples. a) Natural names: *Bennettitales, Ginkgoales, Podocarpaceae, Cibotium polaris* K—M. b) Semi-natural names: *Piceites variabiliformis* (MAL.) (=*Orbicularia variabiliformis* MAL.), *Todites* sp. etc.) Artificial names: *Leiotriletes microdiscus* K—M. This threefold character

of nomenclature was defined in the works of Potonié, Thomson and Thiergart (1950) and Potonié (1952) in first line in the relation of the terciary sporomorphs. This method was applied by Bolkhovitina (1961) in the monography about *Schizaeaceae* spores and in her new work (Bolkhovitina [1962]), and by Korotkevich (1961), Kurnosova (1960), Malyavkina (1962), Markova (1962), Molin (1961), Romanovskaya (1962) and by other authors too.

4. The work of Couper (1958) was a landmark in the investigation of mesozoic spores and pollens. In his monography he prefers the semi-natural names. It is an interesting effort of his, according to which on the basis of the investigation of associated spores of several megafossilia he attempts to connect nomenclaturally the dispers and associated spores. e. g. he described the genus *Klukisporites* for the dispers spores which are morphologically similar to the spores which are known from the sporangia of the makrofossilium *Klukia.* He described the genus *Todisporites* which spores are similar to the spores of the *Todites* residues. This effort is modern and remarkable. The genera, however, which are properly described on the basis of the morphographic systems must be left out of consideration and so, according to the rule of priority, several new genera introduced by him became invalid. These discrepancies of Couper's work (1958) were demonstrated in connection with the genus *Klukisporites* by Stanley and Pocock (1962) too. According to the rule of priority the spores described by Couper in 1958 as *Klukisporites* belong to the genus *Dictyotriletes* (Naumova) Pot. and Kr. 1954.

5. The use of artificial systems manifest itself in the work of Lantz (1958), who applied the formal categories described in the fundamental works of Luber (1955), Balme (1957), Erdtman (1947), Delcourt and Sprumont (1955), Potonié and Gelletich (1933), Weyland and Krieger (1953), Weyland and Greifeld (1953), Potonié and Kremp (1954), Pflug (1952) and others. In addition he used semi-natural names too, in first line on the basis of the works of Couper (1953, 1958), Potonié (1951), Potonié and Venitz (1934) and Potonié, Thomson and Thiergart (1950).

This latter method suits for the most part authors' conception which will be reviewed later. First, however, some general problems of the nomenclature of mesozoic sporomorphs must be taken into consideration.

1. In contrast to the clear explanation of Rouse (1957), according to which it is extremely wrong and irregular to describe new species in recent genera on the basis of the morphology of fossil dispers spores and pollens, several authors act in this manner. It is regrettable that the clear and fundamental arguments of Rouse (1957) did not attain wide-ranging recognition. The essence of Rouse's theses are the followings:
of Rouse's theses are the followings:

a) The species-diagnosis of a recent plant is based on the properties of the sporophyton generation.

b) The gametophyton generation is in several cases aspecific.

2. Because the recens species are inseparable on the basis of spores and pollens, it is a just supposition that the „species" described on the basis of fossil sporomorphs in the reality include several extinct species. Therefore will be considered the „species" of *„Sporae dispersae"* as formal categories and the designations form-genus (fgen.) and form-species (fsp.) known from several works of Krutzsch will be used.

Taking into consideration that the efforts trended to the unification of the nomenclature of *Sporae dispersae* remained ineffective till now, and in the present situation a solution is not expected in the near future, authors' work does not raise a claim of the solution of the problem. They only outline their present point of view:

1. Authors do not accept taxa, which are irregularly described, including the „species" ranged into recens genera.

2. As a basis serve the artificial systems and the new species will be described and arranged into formal categories. From the point of view of the botany this is the most proper method, because the representants of the vegetation of the Mesophyticum are not to connect directly with the recens genera, especially not on the basis of their gametophyton generation.

3. Authors made an effort to detect the priority of each genera and according to this they emended the species arranged in other genera — as far as this was possible.

4. Before each category the list of the form-species reviewed in the followings is given, for easier to manage the work.

5. In the qualitative part of the results only a part of the spores will be treated according to the system of the work of KRUTZSCH (1959). Further results concerning the spores and the pollens and microplancton will be treated in a following work.

RESULTS

Sporites H. Potonié 1893

TRILETES REINSCH 1881
AZONOTRILETES LUBER 1935
LAEVIGATI (B. and K. 1868) R. POT. and KR. 1954

Fgen.: LEIOTRILETES (NAUMOVA 1937) R. POT. and KR. 1954

1. *L. manganicus* n. fsp. (Plate I, 1, 2)
2. *L. brevilaesuratus* n. fsp. (Plate I., 3, 4)
3. *L. urkutensis* n. fsp. (Plate I., 5, 6)
4. *L. sphagnoides* n. fsp. (Plate I., 7—10)
5. *L. transdanubicus* n. fsp. (Plate I., 11, 12)
6. *L. complicatus* (LESCHIK 1955) n. comb. (Plate I., 13, 14)
7. *L. globosus* (LESCHIK (1955) n. comb. (Plate II., 5, 6)
8. *L. pflugi* SIMONCSICS and KEDVES 1961 (Plate II., 1, 2)

L. pflugi SIMONCSICS and KEDVES 1961 fvar. *triplan* SIMONCSICS and KEDVES 1961 (Plate II., 3, 4)

1. *Leiotriletes manganicus* n. fsp. (Plate I., 1, 2)

Diagnosis:

Seen from the pole the contour is triangular, the angles are only slightly rounded off. The exosporium is triplex. The outer lamella is thinner than 1 μ. The middle lamella is about 2 μ on the angles, along the side lines thinner. The inner lamella is uniformly 0,5 μ thick. The laesures of the tetrad mark are rectilinear, at the ends slightly bifurcated and they reach the equator.

Maximal measurement: 42 μ.

Holotypus: Plate I., 1, 2, prep. U—III—2—36—1.

Locus typicus: Úrkút, manganese mine, carbonate manganese ore motherlode of the shaft III.

Stratum typicum: Dark-grey, finely streaked clayey marl with manganese content.

Derivatio nominis: from the name of the embedding rock of the holotypus.

Spores of similar morphology:

a) REISSINGER [1950]: *"Kleine Pteridophyten-, wahrscheinlich Farnsporen"* (plate 12, 8); Liassic period.
b) SAH [1955]: *Leiotriletes Type 9;* Salt Range West Punjab (Pakistan), Jurassic period.
c) KARA—MURZA [1960]: *Leiotriletes sp. (Coniopteris sp.?)* Spore of *Triquetrella trisecta* MAL. type. (Plate 12., 6), surroundings of Katangsk, Lower Callovian.

2. *Leiotriletes brevilaesuratus* n. fsp. (Plate I., 3, 4)

Diagnosis:

Seen from the pole the contour is triangular, the angles are widely rounded off. Width of exosporium is 1,8—2 μ, it is duplex, the layers are equally thick. The laesures are recti-linear and do not reach the equatorial contour, $r = {}^2/_3 - {}^4/_5$. The surface is smooth or scabrat.

Maximal measurement: 42 μ.

Holotypus: Table I., 3, 4, prep. U—III—2—68—3.

Locus typicus: Úrkút, manganese mine, carbonate manganese ore motherlode of the shaft III.

Stratum typicum: Dark-grey, finely streaked clayey marl with manganese carbonate content.

Derivatio nominis: from the relatively short laesures.

Spore of similar morphology:

a) BOLKHOVITINA [1956]: *Adiantum mollis* BOLKHOVITINA; Yakutsk A. S. S. R., Kangalassy, Upper Jurassic period.

3. *Leiotriletes urkutensis* n. fsp. (Plate I., 5, 6).

Diagnosis:

Seen from the pole the contour is triangular with rounded off angles. The exosporium is rather thin, always below 1 μ. The surface is finely scabrat. The laesures of the tetrad mark are slightly wavy and they reach the equator.

Maximal measurement: 44 μ.

Holotypus: Table I., 5, 6, prep. U—III—4—27.

Locus typicus: Úrkút, manganese mine, carbonate manganese ore motherlode of the shaft III.

Stratum typicum: green, grey, finely streaked carbonate manganese ore.

Derivatio nominis: from Úrkút, the site of holotypus.

Spores of similar morphology:

a) MINER [1935]: *Deltoidospora cascadensis* MINER 1935; Lower Cretaceous.
b) BOLKHOVITINA [1953]: *Leiotriletes varius* BOLKHOVITINA 1953; Western Kazakhstan. Lower Cretaceous.
c) BOLKHOVITINA [1953]: *Hausmannia anonyma* BOLKHOVITINA 1953 (=*Leiotriletes anonymus* BOLKHOVITINA 1953); Moscow region Dimitrov district, Volguska River Settlement Paramonovo, Lower Cretaceous.

d) LESCHIK [1955]: *Laevigatisporites tenuis* LESCHIK 1955; Upper Triassic (Keuper stage).
e) SAH [1955]: *Leiotriletes Type 6* (Pl. 1, fig. 7); Salt Range West Punjab (Pakistan), Jurassic period. SAH [1955] compared the spore observed by him with the followings: *Coniopteris hymenophylloides* BRONG., *Thyrsopteris elegans* KZE., *Eboracia lobifolia* — THOMAS 1911 — *Cladophlepis (Eboracia) lobifolia* — SZE 1933—.
f) COUPER [1958]: *Coniopteris hymenophylloides* (BRONGNT.) (Plate 20., 5); Middle Jurassic period.
g) ROUSE [1959]: *Deltoidospora psilostoma* ROUSE 1959; Kootenay (British Columbia), Upper Jurassic period.
h) KARA—MURZA [1960]: *Coniopteris sp.* (Plate 3, 3); surroundings of Katangsk, Middle Triassic period (Ladinian?).
i) KURNOSOVA [1960]: *Coniopteris sp.* (Plate 2, 6); surroundings of Krasnoyarsk, Lower Jurassic period.
j) KURNOSOVA [1960]: *Coniopteris sp.* (Plate 5, 9); surroundings of Krasnoyarsk, Upper Jurassic period.

4. *Leiotriletes sphagnoides* n. fsp. (Plate I., 7—10).

Diagnosis:

Seen from the pole the contour is triangular with rounded off angles. The sides are almost straight, locally a slightly concave, sometimes a little convex. Exosporium is about 1,5 μ thick, duplex. The thickness of the ectexosporium and endexosporium is about the same. The surface is smooth or slightly scabrat. The laesures of the tetrand mark are long, but they reach only rarely the equator, $r = {}^2/_3 - {}^5/_5$.

Maximal measurement: 30 μ.

Holotypus: Plate I., 7, 8, prep. U—III—6—1., 3,5/69,5.

Locus typicus: Úrkút, manganese mine, carbonate manganese ore motherlode of the shaft III.

Stratum typicum: green, grey, finely streaked carbonate manganese ore.

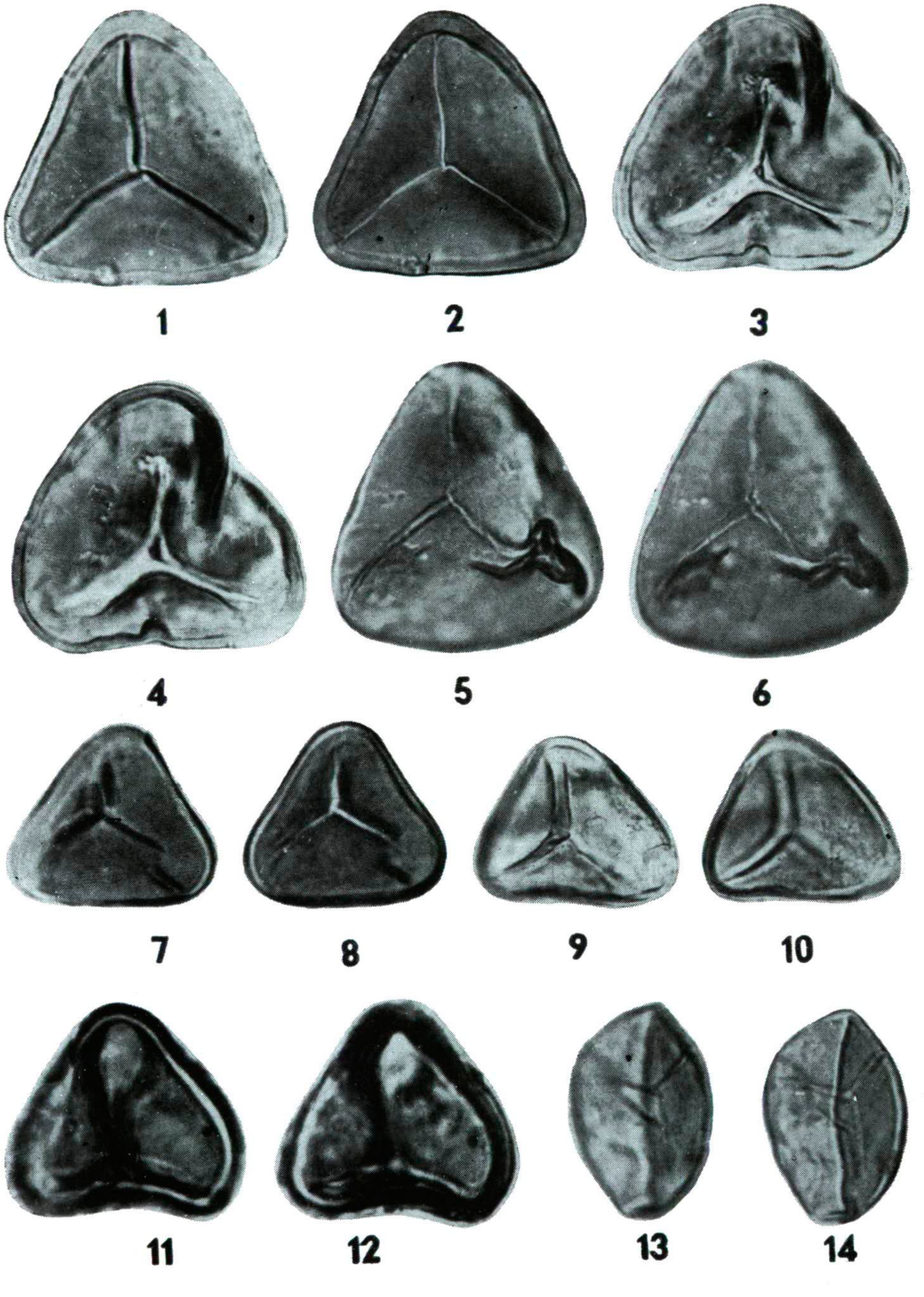
Derivatio nominis: from several similarities with the spores of Sphagnaceae.

Spores of similar morphology:

a) MINER [1935]: *Deltoidospora hallii* MINER 1935; Lower Cretaceous period.
b) BOLKHOVITINA [1953]: *Leiotriletes varius* BOLKHOVITINA 1953; Lower and Middle Albian stage.
c) KARA—MURZA [1960]: *Stenozonotriletes gracilis* K.—M.—; surroundings of Katangsk, Middle Liassic period.
d) KARA—MURZA [1960]: *Coniopteris cf. onychioides* VAS. et K.—M.; surroundings of Katangsk, Aptian stage.

Plate I.

1, 2. — *Leiotriletes manganicus* n. fsp. (U—III—2—36—1)
3, 4. — *Leiotriletes brevilaesuratus* n. fsp. (U—III—2—68—3)
5, 6. — *Leiotriletes urkutensis* n. fsp. (U—III—4—27)
7, 8. — *Leitriletes sphagnoides* n. fsp. (U—III—6—1, 3, 5/69, 5)
9, 10. — *Leiotriletes sphangnoides* n. fsp. (U—III—3—76—2)
11, 12. — *Leiotriletes transdanubicus* n. fsp. (U—III—3—1, 16/81)
13, 14. — *Leiotriletes complicatus* (LESCHIK 1955)n. comb.
1000×



e) KURNOSOVA [1960]: *Gleichenia sp.* (Plate 4, 1, 1/a); surroundings of Krasnoyarsk, Middle Jurassic period.
f) KURNOSOVA [1960]: *Thyrsopteris pyramidalis* K.—M.; surroundings of Krasnoyarsk, Middle Jurassic period.

5. *Leiotriletes transdanubicus* n. fsp. (Plate I., 11, 12).

Diagnosis:

Seen from the pole the contour is triangular, the angles are only slinghtly rounded off. The side lines are slightly convex or concave. The exosporium is 2—2,5 μ thick, double-layered, the ectexosporium and the endexosporium are equally thick. The surface is smooth. The laesures almost reach the equator, $r = 4/5$.

Maximal measurement: 33 μ.

Holotypus: Plate I. 11, 12, prep. U—III—3—1, 16/81.

Locus typicus: Úrkút, manganese mine, carbonate manganese ore motherlode of the shaft III.

Stratum typicum: Green, grey, finely streaked carbonate manganese ore.

Derivatio nominis: from the site of the holotype, Transdanubia.

Notes. — It occured in very great quantity, especially in the lower third part of the layer. It is interesting that the exemplares observed were in triplaniod situation without exception.

6. *Leiotriletes complicatus* (LESCHIK 1955) n. comb. (Plate I., 13, 14).

Syn.: 1955 — LESCHIK, *Laevigatisporites complicatus* LESCHIK.

Seen from the pole the contour is triangular with rounded off angles. The exosporium is 0,8—1,3 μ thick. The ectexosporium and the endexosporium are equally thick. Sometimes the latter is thicker. The ectexosporium is smooth, the endexosporium is chagrenat of finely punctat. The laesures are long, but do not always reach the peaks of the spore.

Maximal measurement: according to LESCHIK (1955) 33×17 μ, the exemplares of Úrkút are about 31 μ.

Notes: The form-species was described from the Keuper by its author and as botanical connection he designs *?Calamariaceae*. It is interesting, that the typical spores and the spores known from the manganese ore, are equally „pseudotriplan" forms.

Spore of similar morphology:

a) KARA—MURZA [1960]: *Equisetites rotundus* (NAUM.) (=*Leiotriletes rotundus* NAUM.); surroundings of Katangsk, Middle Triassic period (Anizian).

7. *Leiotriletes globosus* (LESCHIK 1955) n. comb. (Plate II., 5, 6).

Syn.: 1955 — LESCHIK, *Laevigatisporites globosus* LESCHIK.

Seen from the pole, the contour is triangular with considerable rounded off angles, or circular. The exosporium is thin, about 1μ, the surface is smooth,

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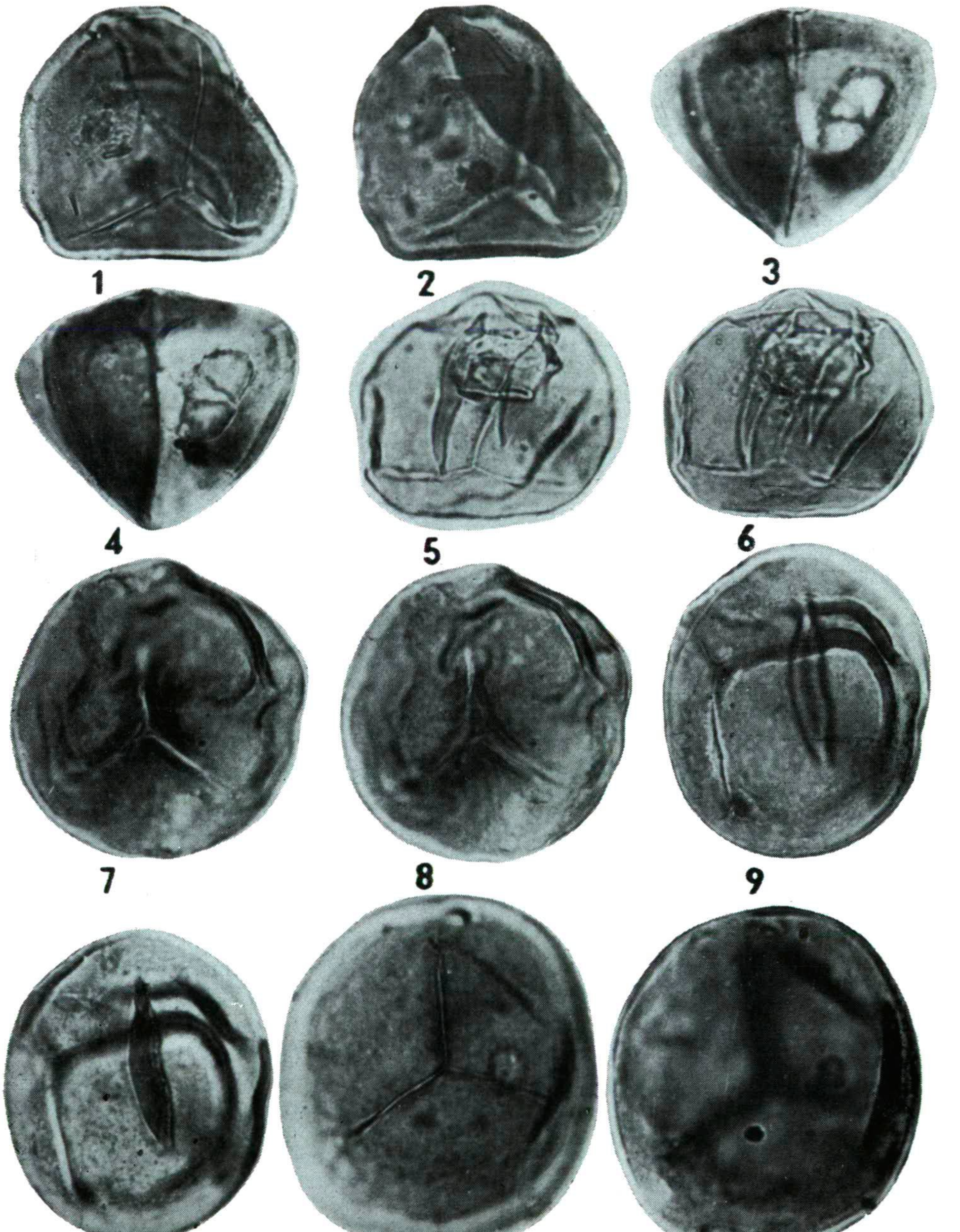
Plate II.

1, 2. — *Leiotriletes pflugi* SIMONCSICS & KEDVES 1961 (U—III—2—51—3)
3, 4. — *Leiotriletes pflugi* SIMONCSICS & KEDVES 1961 fvar. *triplan* SIMONCSICS & KEDVES 1961 (U—III—6—28)
5, 6. — *Leiotriletes globosus* (LESCHIK 1955) n. comb. (U—III—35—1)
7, 8. — *Punctatisporites krutzschi* n. fsp. (U—III—25—94—3)
9, 10. — *Punctatisporites goczani* n. fsp. (U—III—2—51—2)
11, 12. — *Punctatisporites goczani* n. fsp. (U—III—20—118)
1000×

Plate II.



the endexosporium is finely punctat. The laesures are long, generally they reach the equatorial contour, $r = 4/5-5/5$.

Maximal measurement: according to LESCHIK [1955] 33—37 μ, the exemplares of Úrkút are about 36 μ.

Together with the above mentioned form — species also this one was found first from Keuper layers.

8. *Leiotriletes pflugi* SIMONCSICS and KEDVES 1961. (Plate II., 1, 2).
Leiotriletes pflugi SIMONCSICS and KEDVES 1961 fvar. *triplan* SIMONCSICS and KEDVES 1961 (Plate II., 3, 4).

In the course of author's investigations occured this spores in great quantity especially from the third layer of the profil.

Fgen: PUNCTATISPORITES IBRAHIM 1933

1. *P. krutzschi* n. fsp. (Plate II., 7, 8)
2. *P. goczani* n. fsp. (Plate II., 9—12)
3. *P. circulus* n. fsp. (Plate III., 5—8)
4. *P. major* (COUPER 1958) n. comb. fvar. *pseudotriplan* n. fvar. (Plate III., 1, 2)
5. *P. parvigranulosus* LESCHIK 1955 (Plate III., 3, 4)

1. *Punctatisporites krutzschi* n. fsp. (Plate II., 7, 8)

Diagnosis:

Seen from the pole the contour is circular. The thickness of exosporium is always less than 1 μ. The ectexosporium and the endexosporium have the same measure. The structure is finely punctat. Ornamental elements are equally distributed, except the region of the laesures where they are located more densely in a stripe of about 3 μ. The laesures of the tetrad mark are short and do not do not reach the equatorial contour. $r = 1/2-3/4$.

Maximal measurement: 43 μ.

Holotypus: Plate II., 7, 8, prep. U—III—25—94—3.

Locus typicus: Úrkút, manganese mine, carbonate manganese ore motherlode of the shaft III.

Stratum typicum: Rhodochrozit containing grey manganese ore powdered with pyrit.

Derivatio nominis: from DR. W. KRUTZSCH, the excellent investigator of fossile sporomorphs.

Notes. — The thin exosporium of the new form-species described is generally wrinkled. This and the relatively short laesures remind of *Calamospora* S. W. and B. 1944 and of *Monoleiotriletes* KRUTZSCH 1959 in younger sediments. The characteristic structure of the exosporium definitely delineates it from the other genera mentioned.

Spores of similar morphology:

a) BOLKHOVITINA [1956]: *Leiotriletes glaber* (NAUMOVA 1938) WALTZ 1941 var. *mesozoicus* BOLKHOVITINA 1956; Yakutsk District and Kangalassy. Upper Jurassic period.

2. *Punctatisporites goczani* n. fsp. (Plate II., 9—12).

Diagnosis:

Seen from the pole the contour is circular or ellipsoid. The exosporium is about 0,8—1,2 μ thick. The ectexosporium is a little thicker, than the endexosporium. The surface of the spore is very densely punctat, covered with ornamented elements. The laesures of the tetrad mark are straight, generaly they do not reach the equatorial contour, $r = 4/5$, exceptionally $5/5$.

Maximal measurement: 48 μ.

Holotypus: Plate II., 11, 12, prep. U—III—20—118.

Isotypus: Plate II., 9, 10, prep. U—III—2—51—2.

Locus typicus: Úrkút, manganese mine, carbonate manganese ore motherlode of the shaft III.

Stratum typicum: Brown, redbrown, locally roughly streaked manganese ore.

Derivatio nominis: from Dr. F. GÓCZÁN, the excellent investigator of the Hungarian mesozoic sporomorphs.

Spores of similar morphology:

a) WEYLAND and GREIFELD [1953]: *Punctatisporites rotundus* WEYLAND and GREIFELD 1955; Quedlinburg, Harz, Upper Cretaceous, 1. Senon.
b) LESCHIK [1955]: *Punctatisporites ambiguus* LESCHIK 1955; Upper Triassic period, Middle Keuper stage.
c) SAAD [1963]: *Leiotriletes sp. Type A* (Plate 33, 4); Euone Moussa district, West of Sinai, Middle Jurassic period, particularly Bajocian stage.

3. *Punctatisporites circulus* n. fsp. (Plate III., 5—8)

Diagnosis:

Seen from the pole the contour is circular or triangular with considerable rounded off angles. The thickness of the exosporium is less than 1 μ, generally it is about 0,8 μ. The ectexosporium is somewhat thicker than the endexosporium. The surface is punctat, locally finely scabrat. Along the equator the ornamental elements are radially located. The laesures of the tetrad mark are straight or slightly waved and generally they reach the equator, $r = 4/5$—$5/5$.

Maximal measurement: 37 μ.

Holotypus: Plate III., 5, 6, prep. U—III—2—1, 14, 5/96, 2.

Isotypus: Plate III., 7. 8.

Locus typicus: Úrkút, manganese mine, carbonate manganese ore motherlode of the shaft III.

Stratum typicum: Dark-grey, finely streaked clayey marl with manganese carbonate content.

Derivatio nominis: from its characteristic contour.

4. *Punctatisporites major* (COUPER 1958) n. comb. fvar. *pseudotriplan* n, fvar. (Plate III., 1, 2.)

Syn.: 1958 — COUPER, *Todisporites major* COUPER.

COUPER [1958] arranged the dispers spores similar to the spores prepared from the macrofossilia *Todites williamsonii* and *Todites princeps* into the genus *Todisporites* COUPER 1958. His establishments about the surface of the spores according to which this surface is smooth or finely scabrat are not wholly acceptable, regarding the published figures. One part of the spores arranged into the form-genus *Todisporites* COUPER 1958 may be arranged without any difficulty into the form-genus *Punctatisporites* IBRAHIM 1933. So the genus *Todisporites* COUPER 1958 may be partly considered as the synonime of *Punctatisporites* IBRAHIM 1933. The spores of similar type with smooth surface belong literally to *Leiotriletes* (NAUMOVA 1937) R. POT and KR. 1954.

The exemplares observed in the manganese ore were pseudotriplan without exeption. The thickness of the exosporium were about 1,—1,5 μ. The ectexosporium is somewhat thicker than the endexosporium. The surface is finely punctat, locally scabrat.

5. *Punctatisporites parvigranulosus* LESCHIK (Plate III., 3, 4)

The contour is circular or secondary deformed ellipsoid or triangular with rounded off angles. The exosporium is single-layered, about 1 μ. The surface is punctat. The laesures of the tetrad mark are straight but they do not reach the equator. $r = {}^{3}/_{4} - {}^{4}/_{5}$.

Maximal measurement: 60 μ.

The measures of the exemplares found in the manganese ore are somewhat larger than the exemplares observed by LESCHIK [1955]. This only quantitative differences give no reason for exclusion the forms observed by us from LESCHIK's [1955] form-species. As botanical connections for this form KRÄUSEL and LESCHIK [1955] mentioned the *Dipteridaceae* or the *Matoniaceae*. These forms were described first from layers of the Keuper stage.

Fgen.: SPHAGNUMSPORITES RAATZ 1937.

1. *Sp. psilatus* (ROSS) COUPER 1958 (Plate III., 9, 10)
2. *Sp. clavus* (BALME) DE JERSEY 1959 (Plate III., 11—14)

1. *Sphagnumsporites psilatus* (ROSS) COUPER 1958 (Plate III., 9, 10)

Seen from the pole the contours are triangular with rounded off angles. The exosporium is double-layered. The thickness of the ectexosporium and the endexosporium is the same. The laesures of the tetrad mark reach nearly the equatorial contour, $r = {}^{3}/_{4} - {}^{4}/_{5}$. The surface is wavely ornamented consisting of slightly emerged verrucae-like elements.

The maximal measure of the exemplares observed is about 30 μ. According to COUPER [1958] the form-species is frequent in Jurassic and Lower Cretaceous layers.

2. *Sphagnumsporites clavus* (BALME) DE JERSEY 1959 (Plate III., 11—14)

Maximal measurement occured in our material is 28—39 μ. The laesures of the tetrad mark are long, sometimes they reach the equator. The thickness of exosporium is about 2 μ. The ectexosporium is thicker, than the endexosporium. The surface is ornamented with large and flat elements.

Plate III.

1, 2. — *Punctatisporites major* (COUPER 1958) n. comb. fvar. *pseudotriplan* n. fvar. (U—III—47)
3, 4. — *Punctatisporites parvigranulosus* LESCHIK 1955 (U—III—3—1, 17, 5/77, 5)
5, 6. — *Punctatisporites circulus* n. fsp. (U—III—2—1, 14, 5/96, 2)
7, 8. — *Punctatisporites circulus* n. fps.
9, 10. — *Sphagnumsporites psilatus* (ROSS) COUPER 1958.
11, 12. — *Sphagnumsporites clavus* (BALME) DE JERSEY 1959.
13, 14. — *Sphagnumsporites clavus* (BALME) DE JERSEY 1959.
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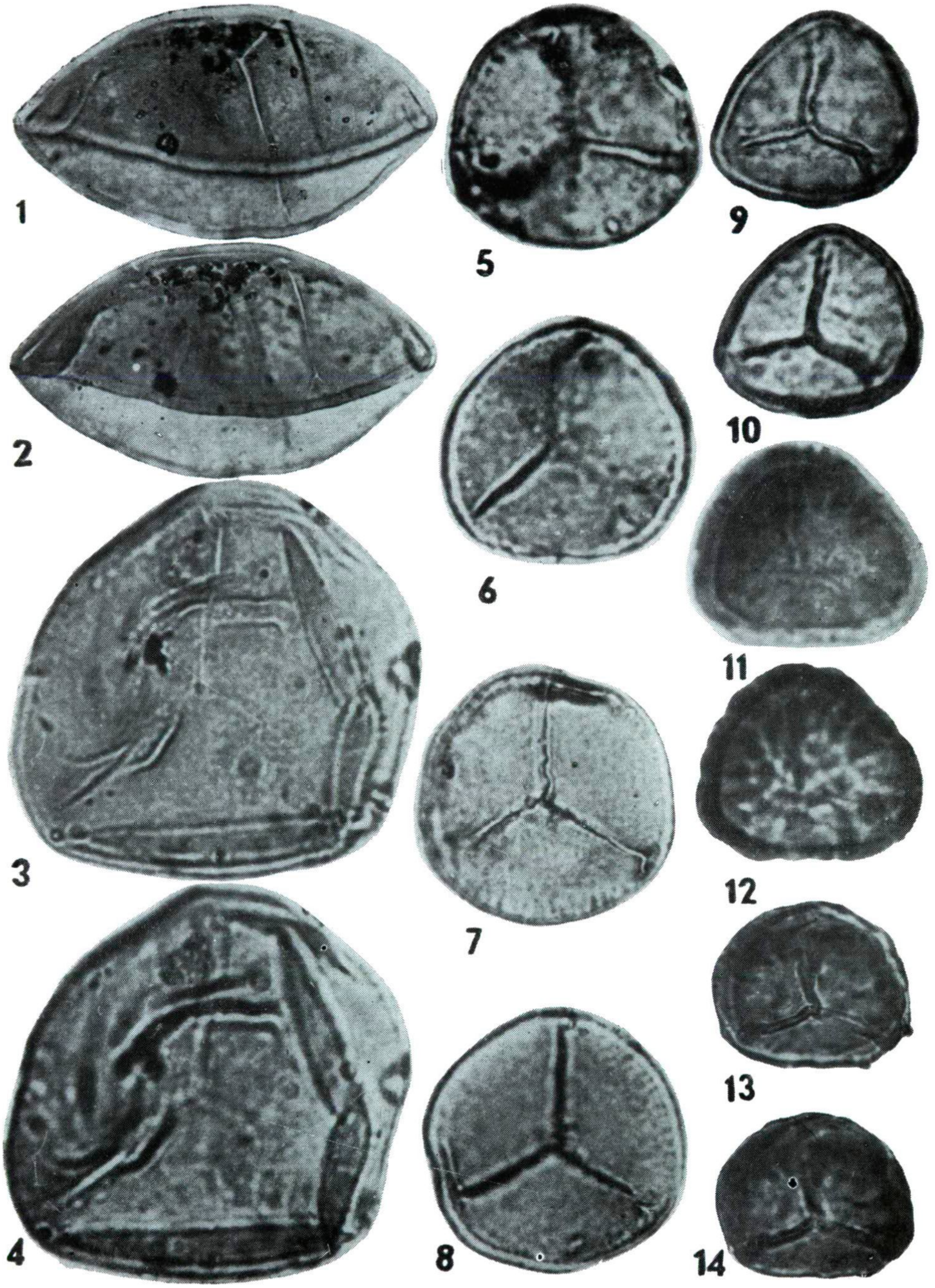
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TRIPLANES (Pf. 1953) KRUTZSCH 1959.
Fgen.: TRIPLANOSPORITES PF. 1952 emend. TH. and PF. 1953.

1. *Tr. couperi* n. fsp. (Plate IV., 1)
2. *Tr. goczani* n. fsp. (Plate IV., 2, 3)
3. *Tr. manganicus* n. fsp. (Plate IV., 4)

Notes. — In connection with this form-genus it must be emphasized, that all form-species must be considered as provisoric ones due to their „triplan" characteristic. This characteristic is only a state of maintenance of the trilete spores (cf. H. DEÁK [1959], KEDVES [1961]).

The trilet form of the three form-species described below are not yet known. If in the course of subsequent investigations the original trilet forms will be discovered, than these forms must be naturally rearranged as the triplan form varieties of the trilet forms.

1. *Triplanosporites couperi* n. fsp. (Plate IV., 1)

Diagnosis:

The equatorial contour is considerably concave, the length of the polar axis is about 52 μ and is about the same as that of the equator. The thickness of the exosporium is 1—1,3 μ. The exosporium is double layered. The ectexosporium and the endexosporium have the same thickness. The surface is smooth or finely scabrat.

Holotypus: Plate IV., 1, prep. U—III—3—69—1.

Locus typicus: Úrkút, manganese mine, carbonate manganese ore motherlode of the shaft III.

Stratum typicum: Green, grey finely streaked manganese ore with carbonate content.

Derivatio nominis: from. Dr. R. A. COUPER, the excellent investigator of the British mesozoic spores and pollens.

2. *Triplanosporites goczani* n. fsp. (Plate IV., 2, 3)

Diagnosis:

The equatorial contour is considerable concave. The polar axis is shorter than the equatorial one. (polar axis 39 μ, equatorial axis 48 μ). The thickness of exosporium is 1,8—2 μ, it is double layered. The ectexosporium and the endexosporium have the same thickness. The structure is scabrat or intrapunctat.

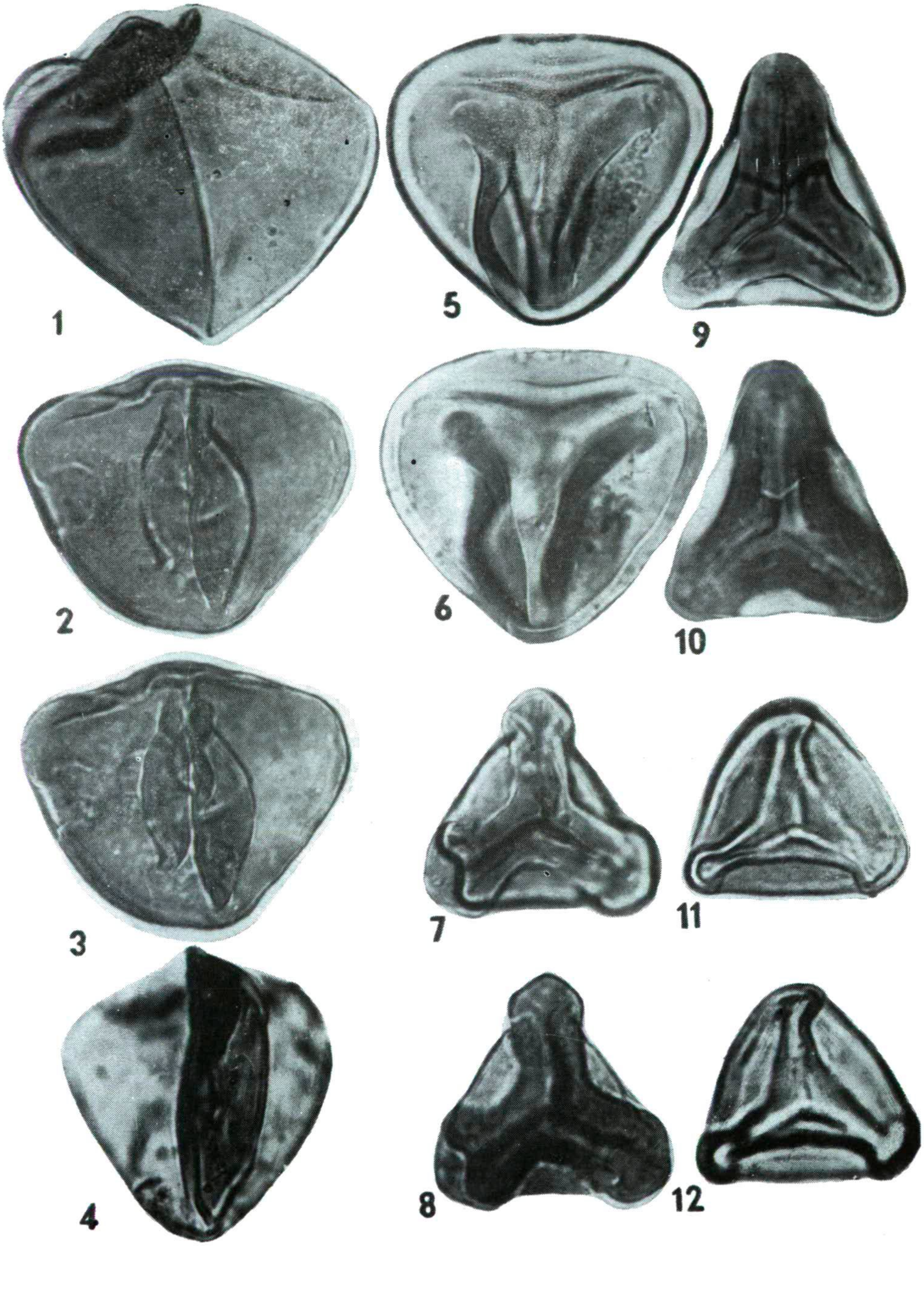
Holotypus: Plate IV., 2, 3, prep. U—III—2—1—1.

Locus typicus: Úrkút, manganese mine, carbonate manganese mother lode of the shaft III.

Plate IV.

1. — *Triplanosporites couperi* n. fsp. (U—III—3—69—1)
2, 3. — *Triplanosporites goczani* n. fsp. (U—III—2—1—1)
4. — *Triplanisporites manganicus* n. fsp. (U—III—2—1—2)
5, 6. — *Toroisporis (Toroisporis) crassiexinus* n. fsp. (U—III—2—62—1)
7, 8. — *Toroisporis (Toroisporis) crassitorus* n. fsp. (U—III—2—124—1)
9, 10. — *Toroisporis (Toroisporis) toralis* (LESCHIK 1955) n. comb. (U—III—3—82)
11, 12. — *Toroisporis (Toroisporis) macrosinus* n. fsp. (U—III—4—1, 17/74, 5)
1000×

Plate IV.



Stratum typicum: Dark-grey, finely streaked clayey marl with manganese carbonate content.

Derivatio nominis: from Dr. F. GÓCZÁN the excellent investigator of the Hungarian mesozoic spores and pollens.

Spores of similar morphology:

a) GÓCZÁN [1956] „*Fernspore type 4/d*"; Komló, Liassic carboniferous layers.

3. *Triplanosporites manganicus* n. fsp. (Plate IV., 4)

Diagnosis:

The equatorial contour is considerable concave. The length of the equatorial axis is less than the polar one. (polar axis: 44 μ, equatorial axis: 39 μ). The thickness of exosporium are generally 0,8 μ and it does not reach the 1 μ. The ectexosporium and the endexosporium have the similar thickness. The surface is smooth or finely scabrat.

Holotypus: Plate IV., 4, prep. U—III—2—1—2.

Locus typicus: Úrkút, manganese mine, carbonate manganese ore motherlode of the shaft III.

Stratum typicum: Dark-grey, finely streaked clayey marl with manganese carbonate content.

Derivatio nominis: from the site of the holotype.

Spores of similar morphology:

a) REISSINGER [1950]: „*Vermutlich Farnsporen*" (Table 12. 14—16); Liassic period.
b) KARA—MURZA [1960]: *Leiotriletes sp.* (Plate 15, 18); surroundings of Katangsk, Lower Cretaceous — Aptian or Albian stage (?).

TORIATI KRUTZSCH 1959

Fgen.: TOROISPORIS KRUTZSCH 1959

Subfgen: TOROISPORIS (TOROISPORIS KRUTZSCH 1959)

1. *T. (Toroisporis) crassiexinus* n. fsp. (Plate IV., 5, 6)
2. *T. (Torosporis) crassitorus* n. fsp. (Plate IV., 7, 8)
3. *T. (Toroisporis) toralis* (LESCHIK 1955) n. comb. (Plate IV., 9, 10)
4. *T. (Toroisporis) macrosinus* n. fsp. (Plate IV., 11, 12)
5. *T. (Toroisporis) rectitorus* n. fsp. (Plate V., 1, 2)
6. *T. (Toroisporis) curvitorus* n. fsp. (Plate V., 3—6)
7. *T. (Toroisporis) hungaricus* n. fsp. (Plate VI., 1—4)
8. *T. (Toroisporis) reissingeri* n. fsp. (Plate VI., 5, 6)

1. *Toroisporis (Toroisporis) crassiexinus n. fsp.* (Plate VI., 5, 6)

Diagnosis:

Seen from the pole the contour is triangular with rounded off angles. The exosporium is 2,5—3,2 μ thick, the ectexosporium is much thicker than the endexosporium. The surface is scabrat or intrapunctat. The laesures of the tetrad mark are relatively long, but they do not reach the equator. Close to the laesures on both sides at about 1,5—2 μ width the exosporium is more thickened. The torus follows the direction of laesures.

Maximal measurement: 48 μ.

Holotypus: Plate IV., 5, 6, prep. U—III—2—62—1.

Locus typicus: Úrkút, manganese mine, carbonate manganese ore mother-lode of the shaft III.

Stratum typicum: Dark-grey, finely streaked clayey marl with carbonate content.

Derivatio nominis: from the thick exosporium.

Notes: — The above mentioned fsp. is similar to, or perhaps identical with the spore published by GÓCZÁN [1956] from the carboniferous Liassic layers of Komló on his Plate 3., figure 11, named „*Páfrányspóra 4/c*".

2. *Toroisporis (Toroisporis) crassitorus* n. fsp. (Plate IV., 7, 8)

Diagnosis:

Seen from the pole the contour is definitely triangular the angles are only rounded off slightly. The torus protrudes from the spore, its width is 4—6 μ (measured from the laesure). Toward the poles it is enlarged or bifurcated. The thickness of the exosporium is about 1 μ, it is double-layered. The thickness of the ectexosporium and the endexosporium is the same. The surface is smooth or scabrat. The laesures of the tetrad mark are long, they reach the equator.

Maximal measurement: 38 μ.

Holotypus: Plate IV., 7, 8, prep. U—III—2—124—1.

Locus typicus: Úrkút, manganese mine, carbonate manganese ore mother-lode of the shaft III.

Stratum typicum: Dark-grey, finely streaked clayey marl with manganese carbonate content.

Derivatio nominis: from the well-developped torus.

Spore of similar morphology:

a) SAAD [1963]: *Concavisporites Type C* (=*C. rugulatus* PFLUG or *Auritulinasporites scanius* NILSSON); Euone Moussa district, West Sinai, Middle Jurassic period, particularly Bajocian stage.

3. *Torisporis (Toroisporis) toralis* (LESCHIK 1955) n. comb. (Plate IV., 9, 10)

Syn.: 1955 — LESCHIK, *Laevigatisporites toralis* LESCHIK.

The contour is definitely triangular, the angles are only slightly rounded off. The exosporium is thin, it is less than 1 μ., it is on the angles somewhat thicker than along the sides. The surface is smooth or scabrat. The laesures are long, but they do not reach the equator, r=4/5. The torus is exceedingly robust, its width is 9—10 μ.

Maximal measurement: 42 μ.

Spores of similar morphology:

a) REISSINGER [1950]: *Sporonites neddeni* R. POT. (Plate 12, 4); Liassic period.
b) BOLKHOVITINA [1956]: *Phlebopteris exornatus* BOLKHOVITINA 1956; Yakutsk A. S. S. R. Sinyaya River, Lower Jurassic period.
c) GÓCZÁN [1956]:*Clathropteris sp.* (6 Type) (Plate 5. 8—12) carboniferous Liassic layers of Komló. GÓCZÁN compared this spores with the spores obtained by WLADIMIROVICH [1950] with the aid of maceration from the sorus-containing leaf-debris of *Clathropteris obovata var. magna* Tur.—Ket.
d) KOROTKEVICH [1961]: *Matonia triassica* K.—M.; U. S. S. R., Arctic region, Lower and Middle Tirassic period.

Notes. — In connection with the botanical relations LESCHIK [1955] mentioned the similarity of the spores of *Cyathea brunonis* WALL., and *Alsophila procera* KAULF.

4. *Toroisporis (Toroisporis) macrosinus* n. fsp. (Plate IV., 11, 12)

Diagnosis:

Seen from the pole the contour is definitely triangular. The exosporium is double-layered, the layers have the same thickness, the wall is 1,5 μ thick. The surface is scabrat. The laesures of the tetrad mark reach almost the equatorial contour. On the proximale side the torus is largely protruding and beside the laesures curved and forms large sinus on the angles. The width of the torus is 5—8 μ, the sinuous torus on the angles is 4—12 μ in diameter.

Maximal measurement: 30 μ.

Holotypus: Plate IV., 11, 12, prep. U—III—4—1, 17/74, 5.

Locus typicus: Úrkút, manganese mine, carbonate manganese ore mother-lode of the shaft III.

Stratum typicum: Green, grey, finely streaked manganese ore with carbonate content.

Derivatio nominis: from the characteristic sinuous form of the torus.

5. *Toroisporis (Toroisporis) rectitorus* n. fsp. (Plate V., 1, 2)

Diagnosis:

Seen from the pole the contour is triangular with rounded off angles and with straight or slightly convex slide lines. From the proximal side the torus is clearly visible, toward the side lines it is delineated with straight or slightly convex lines. The width of the torus is 8—12 μ measured from the proximale peak. The laesures of the tetrad mark are lang, they reach or almost reach the equatorial contour. The wall of the spores on the angles is 2,5—3 μ, along the side lines 1,5 μ, thick, it is double-layered, the inner and the outer parts have about the same thickness. The surface is smooth or slightly scabrat.

Maximal measurement: 58 μ.

Holotypus: Plate V., 1, 2, prep. U—III—1—91—2.

Locus typicus: Úrkút, manganese mine, carbonate manganese ore mother-lode of the shaft III.

Stratum typicum: Dark-grey, finely streaked clayey marl with manganese carbonate content.

Derivatio nominis: from the characteristic form of the torus.

Spore of similar morphology:

a) GÓCZÁN [1956]: *Phlebopteris münsteri* (SCHENK) HIRM. et HOER. (Type 4), Plate 2., 13); carboniferous Liassic layers of Komló.

6. *Toroisporis (Toroisporis) curvitorus* n. fsp. (Plate V., 3—6)

Diagnosis:

Seen from the pole the contour is triangular with rounded off angles. The angles are rounded or slightly angular. The side lines are straight. The torus is parallel with the laesures of the trilet mark and not with the side-lines. It avoids curved the laesures at the peaks. The width of the torus is 7—9 μ. The laesures are straight, they generally reach the peaks and they are at the end

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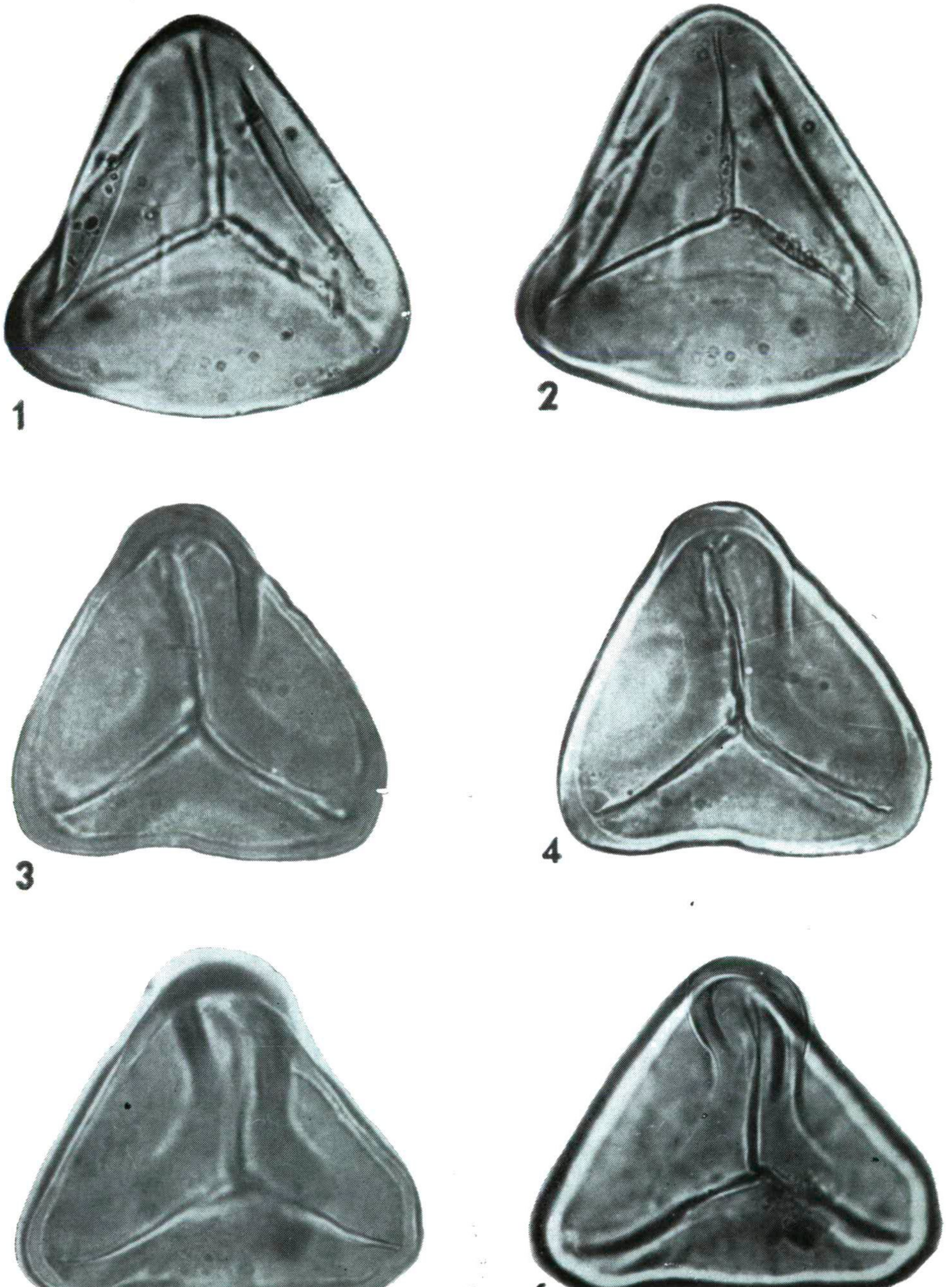
Plate V.

1, 2. — *Toroisporis (Toroisporis) rectitorus* n. fsp. (U—III—1—91—2)
3—6. — *Toroisporis (Toroisporis) curvitorus* n. fsp. (U—III—2—121—4)
1000×

Plate V.



sometimes a little bifurcated. The exosporium has at the angles about a double thickness than at the sides. The exosporium is triplex. The two outer walls are less than 1 μ, the middle wall is 2 μ thick at the angles. The thickness of the side lines is 2 μ or less than 2 μ. The surface is smooth or scabrat.

Maximal measurement: 56 μ.

Holotypus: Plate V., 3—6, prep. U—III—2—121—4.

Locus typicus: Úrkút, manganese mine, carbonate manganese ore motherlode of the shaft III.

Stratum typicum: Dark-grey, finely streaked clayey marl with manganese carbonate content.

Derivatio nominis: from the form of the torus.

Spores of similar morphology:

a) REISSINGER [1950]: Plate 12., 7; Liassic period.
b) SAH [1953]: Plate 1., 2; Ceylon, Jurassic period.
c) SAH [1955]: *Leiotriletes Type 2* (Plate 1., 3, 4); Salt Range West Punjab (Pakistan), Jurassic period.
d) KARA—MURZA [1960]: *Matonia (?) triassica* K.—M. (Plate 1., 7, 8) surroundings of Katangsk, Triassic period (Ladinian?) stage.
e) SAAD [1963]: *Concavisporites sp. Type B (Gleicheniidites senonicus* ROSS 1949 or *Clathropteris sp.* GÓCZÁN [1956]; Euone Moussa district, West of Sinai, Middle Jurassic period, particularly Bajocian stage.

7. *Toroisporis (Toroisporis) hungaricus* n. fsp. (Plate VI., 1—4)

Diagnosis:

Seen from the pole the contour is a triangle with rounded off angles and with convex or seldom slightly concave sides. The thickness of exosporium is 1,8—2,3 μ, it is double layered. The ectexosporium is thicker than the endexosporium. The surface is finely scabrat or intrapunctat. The laesures of the tetrad mark are straight, they almost reach the equatorial contour, $r = {}^4/_5$. The torus is delineated with regularly curved lines, average width is 5 μ.

Maximal measurement: 35 μ.

Holotypus: Plate VI., 1—4, prep. U—III—20—123—1.

Locus typicus: Úrkút, manganese mine, carbonate manganese ore motherlode of the shaft III.

Stratum typicum: Brown, redbrown, locally roughly streaked manganese ore with carbonate content.

Derivatio nominis: from Hungary, the site of holotype.

8. *Toroisporis (Toroisporis) reissingeri* n. fsp. (Plate VI., 5, 6)

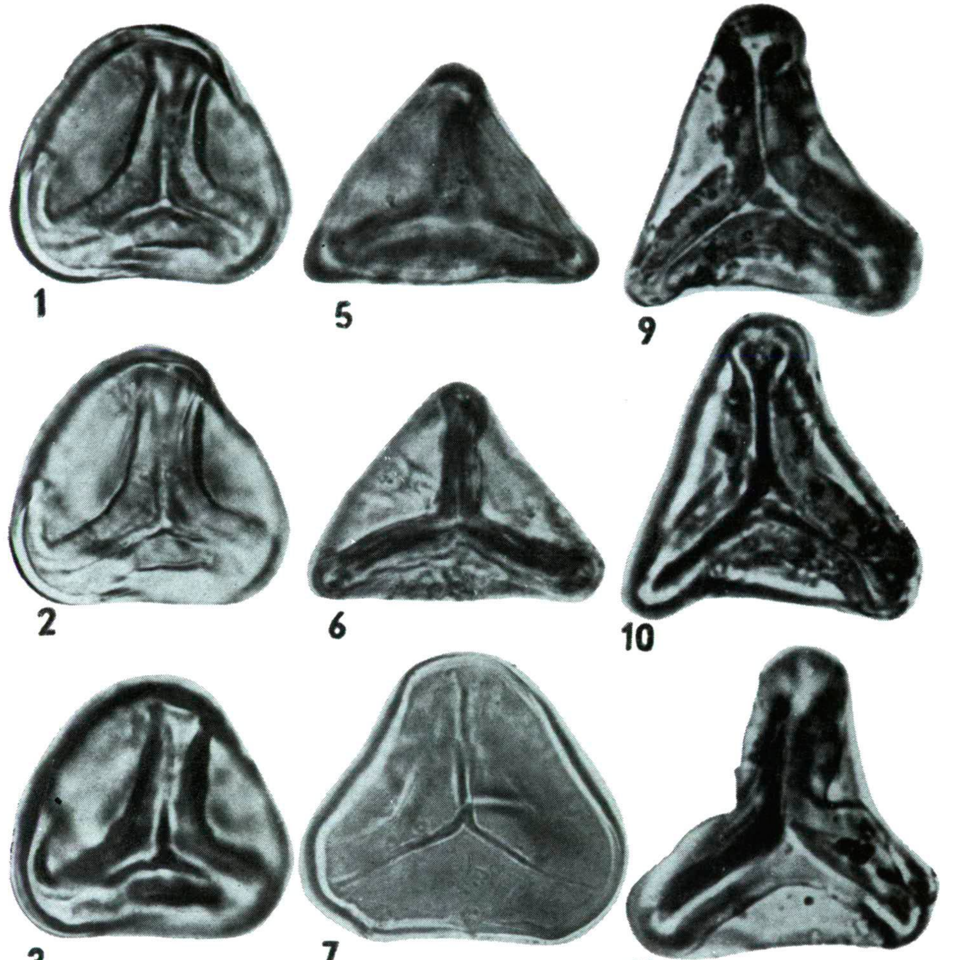
Diagnosis:

Seen from the pole the contour is a regular triangle, the sides are straight, the angles are only slightly rounded off. The exosporium is 2—2,8 μ thick,

Plate VI.

1—4. — *Toroisporis (Toroisporis) hungaricus* n. fsp. (U—III—20—123—1)
5, 6. — *Toroisporis (Toroisporis) reissingeri* n. fsp. (U—III—1—1)
7, 8. — *Concavisporites (Concavisporites) polygonalis* n. fsp. (U—III—2—64—1)
9, 10. — *Concavisporites (Concavisporites) mortoni* (DE JERSEY 1959) DE JERSEY 1962 (U—III—1—1, 16, 5/99)
11, 12. — *Concavisporites (Concavisporites) mortoni* (DE JERSEY 1959) DE JERSEY 1962. 1000×

Plate VI.



double layered. The thickness of ectexosporium and endexosporium is the same. The surface is smooth or finely scabrat. The laesures of the tetrad mark are long and always reach the equatorial contour. The torus surrounding the laesures is well developped, but it is relatively thin, generally 3 μ thick.

Maximal measurement: 42 μ.

Holotypus: Plate VI., 5, 6, prep. U—III—1—1.

Locus typicus: Úrkút, manganese mine, carbonate manganese ore mother-lode of the shaft III.

Stratum typicum: Dark-grey, finely streaked clayey marl with manganese carbonate content.

Derivatio nominis: from Dr. A. Reissinger, the pioneer of the palynology of the Liassic period.

Fgen.: CONCAVISPORITES Pf. 1953
Subfgen.: CONCAVISPORITES (CONCAVISPORITES)

1. *C. (Concavisporites) polygonalis* n. fsp. (Plate VI., 7, 8)
2. *C. (Concavisporites) mortoni* (de Jersey 1959) de Jersey 1962 (Plate VI., 9—12)

1. *Concavisporites (Concavisporites) polygonalis* n. fsp. (Plate VI., 7, 8)

Diagnosis:

Seen from the pole the contour is concave, the angles of the spores are rounded off. The exosporium is double layered, at the angles it is a little thicker than at the sides. At the angles the thickness is 2 μ and at the sides 1—1,5 μ. The suface is smooth or very finely scabrat. The laesures of the tetrad mark reach the peaks. The laesures are accompanied by a well discernible torus.

Maximal measurement: 45 μ.

Holotypus: Plate VI., 7, 8, prep. U—III—2—64—1.

Locus typicus: Úrkút, manganese mine, carbonate manganese ore- mother-lode of the shaft III.

Stratum typicum: Dark-grey, finely streaked clayey marl with manganese carbonate content.

Derivatio nominis: from the form of the spore.

Spore of similar morphology:

a) Kurnosova [1960]: *Lygodium subsimplex* (Naum.) Bolch. (Plate 5, 6); surroundings of Krasnoyarks, Upper Jurassic period.

2. *Concavisporites (Concavisporites) mortoni* (de Jersey 1959) de Jersey 1962 (Plate VI., 9—12)

Spores with concave contour, with characteristically well-developped torus. Maximal measurement of the exemplares observed is about 50 μ. The surface of exosporium is smooth or finely scabrat, it is about 1 μ thick. The ectexosporium and the endexosporium have the same thickness. The laesures of the tetrad mark are long, but do not reach always the equatorial contour.

Notes. — The figures about the spores of this form species published by Dr. de Jersey [1959, 1962] may rise the suggestion that there are here heterogenous forms drawn together into a single category. The exemplares found by us in the manganese ore belong undoubtedly to this form group. This group may be perhaps divided in the future. This revision exceeds the task of this work.

Subfgen.: CONCAVISPORITES (OBTUSISPORIS KRUTZSCH 1959)

1. *C. (Obtusisporis) mesozoicus* n. fsp. (Plate VII., 1, 2)
2. *C. (Obtusisporis) reductus* n. fsp. (Plate VII., 3, 4)
3. *C. (Obtusisporis) undulus* n. fsp. (Plate VII., 5—7)
4. *C. (Obtusisporis) kara—murzae* n. fsp. (Plate VII., 8—9)
5. *C. (Obtusisporis) divisitorus* n. fsp. (Plate VII., 10, 11)
6. *C. (Obtusisporis) hexagonalis* n. fsp. (Plate VII., 12—14)

Notes: — The spores enumerated below belong to this form genus.

a) REISSINGER [1950]: *„Kleine Pteridophyten-, wahrscheinlich Farnsporen"* (Plate 12., 6); Liassic period.
b) GÓCZÁN [1956]: *„Páfrányspóra (cf. Concavisporites montis brassicae* THIERGART) *(type 7)"* (Plate 6., 1—5); carboniferous Liassic period, surroundings of Komló.
c) MOLIN [1961]: *Cibotium junctum* K.—M.; Konin, Jurassic period.
d) SAAD [1963]: *Concavisporites sp. Type E* (probably = *C. sinuatus* (COUPER 1953) KRUTZSCH 1959, = *C. jurienensis* BALME 1957, = *C. montis* THIERGART 1949, = *Triletes sinuatus* COUPER 1953, = *Cibotium junctum* KARA—MURZA, = *Auritulinasporites intrastriatus* NILSSON 1958); Euone district, West of Sinai, Middle Jurassic period, particularly Bajocian stage.

1. *Concavisporites (Obtusisporis) mesozoicus* n. fsp. (Plate VII., 1, 2)

Diagnosis:

Seen from the pole the contour is a concave triangle with slightly pointed angles. The thickness of exosporium is generally 2 μ, at the peaks 2,5 μ, in the middle of the concave slide lines 1,5 μ. The surface is smooth. The laesures of the tetrad mark reach the equator, sometimes they are bifurcated next to the equator. The „obtusi apparatus" is well developped. It has along the laesures torus like emergences.

Maximal measurement: 43 μ.

Holotypus: Plate VII., 1, 2, prep. U—III—5—86—2.

Locus typicus: Úrkút, manganese mine, carbonate manganese ore motherlode of the shaft III.

Stratum typicum: Green, grey finely streaked manganese ore with carbonate content.

Derivatio nominis: from the age of its site.

2. *Concavisporites (Obtusisporis) reductus* n. fsp. (Plate VII., 3, 4)

Diagnosis:

Seen from the pole the contour is very concave with rounded off angles. The surface is smooth, „obtusi apparatus" is reduced, the laesures are slightly wavy, they reach the equator. The thickness of the exosporium ot the peak of the spore is more than 1 μ and at the sides below 1 μ.

Maximal measurement: 43 μ.

Holotypus: Plate VII., 3, 4, prep. U—III—2—71.

Locus typicus: Úrkút, manganese mine, carbonate manganese ore mother-lode of the shaft III.

Stratum typicum: Dark-grey, finely streaked clayey marl with manganese carbonate content.

Derivatio nominis: from the reduced „obtusi apparatus".

3. *Concavisporites (Obtusisporis) undulus* n. fsp. (Plate VII., 5—7).

Diagnosis:

Seen from the pole the contour is a concave triangle with rounded off angles. The „obtusi apparatus" is slightly developped. Near to the proximal pole the laesures are very wavy. The end of the laesures is straight and it reaches the equator. The sculpture is scabrat. The thickness of the exosporium is 1,5 μ, at the peaks and at the sides equally.

Maximal measurement: 35 μ.

Holotypus: Plate VII., prep. U—III—3—75.

Locus typicus: Úrkút, manganese mine, shaft III. carbonate manganese ore mother-lode.

Stratum typicum: Green, grey, finely streaked manganese ore with carbonate content.

Derivatio nominis: from the wavy laesures.

Spore of similar morphology:

a) Kurnosova [1960]: *Cibotium junctum* K.—M.: surroundings of Krasnoyarks. Middle Jurassic period.

4. *Concavisporites (Obtusisporis) kara—murzae* n. fsp. (Plate VII., 8, 9)

Diagnosis:

Seen from the pole the contour is slightly concave. The peaks of the spore are strongly rounded off. The laesures are long but do not reach the peaks of the spore. Between the laesures the exosporium is protruding. The „obtusi apparatus" is strongly developped. The walls are smooth or slightly scabrat with 1,5—2 μ thickness.

Maximal measurement: 30 μ.

Holotypus: Plate VII., 8, 9, prep. U—III—20—2.

Locus typicus: Úrkút, manganese mine, shaft III. carbonate manganese ore mother-lode.

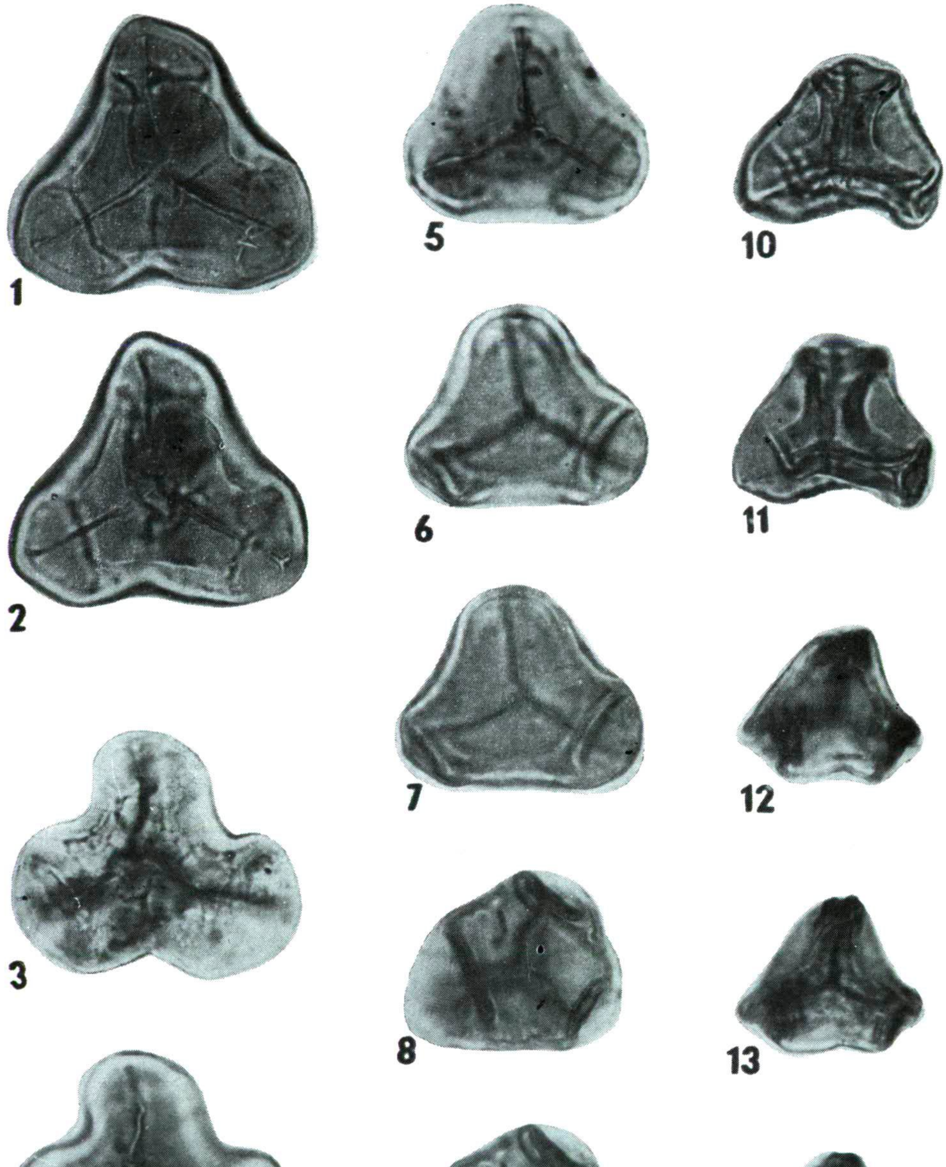
Stratum typicum: Brown, reddish brown, locally roughly streaked manganese ore with carbonate content.

Derivatio nominis: from Dr. Kara—Murza, the excellent investigator of mesozoic sporomorphs.

Plate VII.

1, 2. — *Concavisporites (Obtusisporis) mesozoicus* n. fsp. (U—III—5—86—2)
3, 4. — *Concavisporites (Obtusisporis) reductus* n. fsp. (U—III—2—71)
5—7. — *Concavisporites (Obtusisporis) undulus* n. fsp. (U—III—3—75)
8, 9. — *Concavisporites (Obtusisporis) kara—murzae* n. fsp. (U—III—20—2)
10, 11. — *Concavisporites (Obtusisporis) divisitorus* n. fsp. (U—III—20—1)
12—14. — *Concavisporites (Obtusisporis) hexagonalis* n. fsp. (U—III—25—94—2)
1000×

Plate VII.



Spores of similar morphology:

a) KARA—MURZA [1960]: *Cibotium junctum* K.—M. surroundings of Katangsk, Middle Jurassic period.
b) KURNOSOVA [1960]: *Cibotium corniculatum* BOLCH.; surroundings of Krasnoyarsk, Hauterivian—Barremian.

5. *Concavisporites (Obtusisporis) divisitorus* n. fsp. (Plate VII., 10, 11)

Diagnosis:

Seen from the pole the contour is slightly concave. The peaks of the spore are slightly pointed out. The laesures reach the equator and here and there they are bifurcated. „Obtusi apparatus'' is well developped, between the laesures there is a strong torus, that is 3 μ, maximum 4 μ wide. The torus is bifurcated toward the peaks of the spore. The exosporium is thin, it is always less than 1 μ. The surface is smooth or finely scabrat.

Maximal measurement: 28 μ.

Holotypus: Plate VII., 10, 11, prep. U—III—8—20—1.

Locus typicus: Úrkút, manganese mine, shaft III. carbonate manganese ore mother-lode.

Stratum typicum: Brown, light brown, finely streaked manganese ore with carbonate content.

Derivatio nominis: from the torus bifurcated towards the peaks of the spore.

6. *Concavisporites (Obtusisporis) hexagonalis* n. fsp. (Plate VII., 12—14)

Diagnosis:

Seen from the pole the contour is a concave hexagon. The laesures reach the equator. They are strongly wavy with a well developped torus. The width of the torus is 2—3 μ. The torus is enlarged towards the peaks and it is slightly bifurcated. The exosporium is smooth, near the torus scabrat or intrapunctat. The exosporium is thin, the thickness is always less than 1 μ.

Maximal measurement: 26 μ.

Holotypus: Plate VII., 12—14, prep. U—III—25—94—2.

Locus typicus: Úrkút, manganese mine, carbonate manganese ore mother-lode of the shaft III.

Stratum typicum: Grey, carbonate manganese ore with dispersed pyrite and rhodochrosite content.

Derivatio nominis: from its charcteristic contour.

Spore of similar morphology:

a) KURNOSOVA [1960]: *Cibotium paradoxum* (MAL.) K.—M.; surroundings of Krasnoyarks, Lower Jurassic period.

APICULATI (B. and K.) R. POT. and. KR. 1954

Fgen.: VERRUCOSISPORITES IBRAHIM 1933

1. *V. rarus* n. fsp. (Plate VIII., 1, 2)

1. *Verrucosisporites rarus* n. fsp. (Plate VIII., 1, 2)

Diagnosis:

Seen from the pole the contour is triangular with rounded off angles and concave sides. The thickness of exosporiu mis about 1 μ, the ectexosporium and the endexosporium have the same thickness. The surface is covered with uniformly and sparsely dispersed ornaments. This ornaments are about 0,5 μ high, their basis seen from above has a diameter of about 1 μ. The laesures of the tetrad mark do not reach the equator, r=3/4—4/5.

Maximal measurement: 25 μ.

Holotypus: Plate VIII., 1, 2, prep. U—III—13—1, 5, 5/66, 5.

Locus typicus: Úrkút, manganese mine carbonate manganese ore motherlode of the shaft III.

Stratum typicum: Brown, light brown, finely streaked manganese ore with carbonate content.

Derivatio nominis: from the sparsely verrucated exosporium.

Spores of similar morphology:

a) Bolkhovitina [1956]: *Dennstaedtiites confrarugosus* Bolkhovitina 1956; surrounding of Yakutsk A. S. S. R. Sinyaya River, Lower Jurassic period.
b) Kurnosova [1960]: *Trachytriletes* Naum. (Plate 5., 13); surroundings of Krasnoyarks, Upper Jurassic period.

Fgen.: BACULATISPORITES Thomson and Pflug 1953.

1. *B. spinifer* — (Thiergart 1949) n. comb. (Plate VIII., 3, 4)

1. *Baculatisporites spinifer* (Thiergart 1949) n. comb. (Plate VIII., 3, 4)

Syn.: 1949 — Thiergart, *Sporites spinifer* Thiergart.

The contour is circular or secondary elliptic. The thickness of the exosporium is about 1 μ. The ectexosporium is ornamented with various baculat, gemmat or echinat elements. The measure of the ornaments is about 1 μ. The laesures of the tetrad mark are long but do not reach the contour of the equator, r=3/4—4/5. The measure of the observed forms is about 27 μ.

Spore of similar morphology:

a) Leschik [1955]: *Apiculatisporites spininger* Leschik 1955; Upper Triassic period, Middle Keuper stage.

Notes. — The spore described by Leschik [1955] is only echinat ornamented and it is larger than the spores mentioned by us.

MURORNATI R. Pot. and Kr. 1954

Fgen.: TRILITES Cookson 1947 ex Couper 1953.

1. *T. pulcher* n. fsp. (Plate VIII., 5, 6)
2. *T. couperi* n. fsp. (Plate VIII., 7—9)

1. *Trilites pulcher* n. fsp. (Plate VIII., 5, 6)

Diagnosis:

Seen from the pole the contour is triangular with rounded off angles or nearly circular. The exosporium is 2,5—3 μ thick. The ectexosporium is much thicker than the endexosporium. The laesures of the proximal side reach almost the equatorial contour. R is generally 4/5. The ornaments of the proximale pole consists of flat blurred verrucae, which are not, or only slightly observable along the tetrad mark. The average measure of the ornamental elements is about 4 μ. The distale pole is densely ornamented with well developped elements. The verrucae are frequently pointed and they form frequently rugulat ornaments by fusion. On the latter ornamental elements appear further granulated ornaments sparsely. Diameter of the granules is alweys less than 1 μ.

Maximal measurement: 32 μ.

Holotypus: Plate VIII., 5, 6, prep. U—III—2—1, 16, 5/96.

Locus typicus: Úrkút, manganese mine, carbonate manganese ore motherlode of the shaft III.

Stratum typicum: Dark grey, finely streaked clayey marl with manganese carbonate content.

Derivatio nominis: from its various ornaments.

2. *Trilites couperi* n. fsp. (Plate VIII., 7—9)

Diagnosis:

Seen from the pole the contour is a triangle with rounded off angles. The exosporium is 3—3,5 μ thick. The ectexosporium is thicker than the endexosporium. At the proximale pole the laesures of the tetrad mark reach or almost reach the equatorial contour, $r = {}^4/_5 - {}^5/_5$. The ornaments at the proximale pole are rugulat or hamulat, sometimes verrucat. The ornamental elements are always less than 1 μ. The structure is not characteristic. The ornamental elements on the distale pole and along the equator are always more high than 1 μ. The ornamental elements are mostly verrucae or rarely other ornamental elements.

Maximal measurement: 52 μ.

Holotypus: Plate VIII., 7—9, prep. U—III—6—30.

Locus typicus: Úrkút, manganese mine, carbonate manganese ore motherlode of the shaft III.

Stratum typicum: Green, grey finely streaked manganese ore with carbonate content.

Derivatio nominis: from Dr. A. R. Couper, the excellent investigator of the British mesozoic spores and pollens.

Fgen.: CLAVATISPORITES n. fgen.
Fgen. typus: *Cl. clarus* n. fsp.

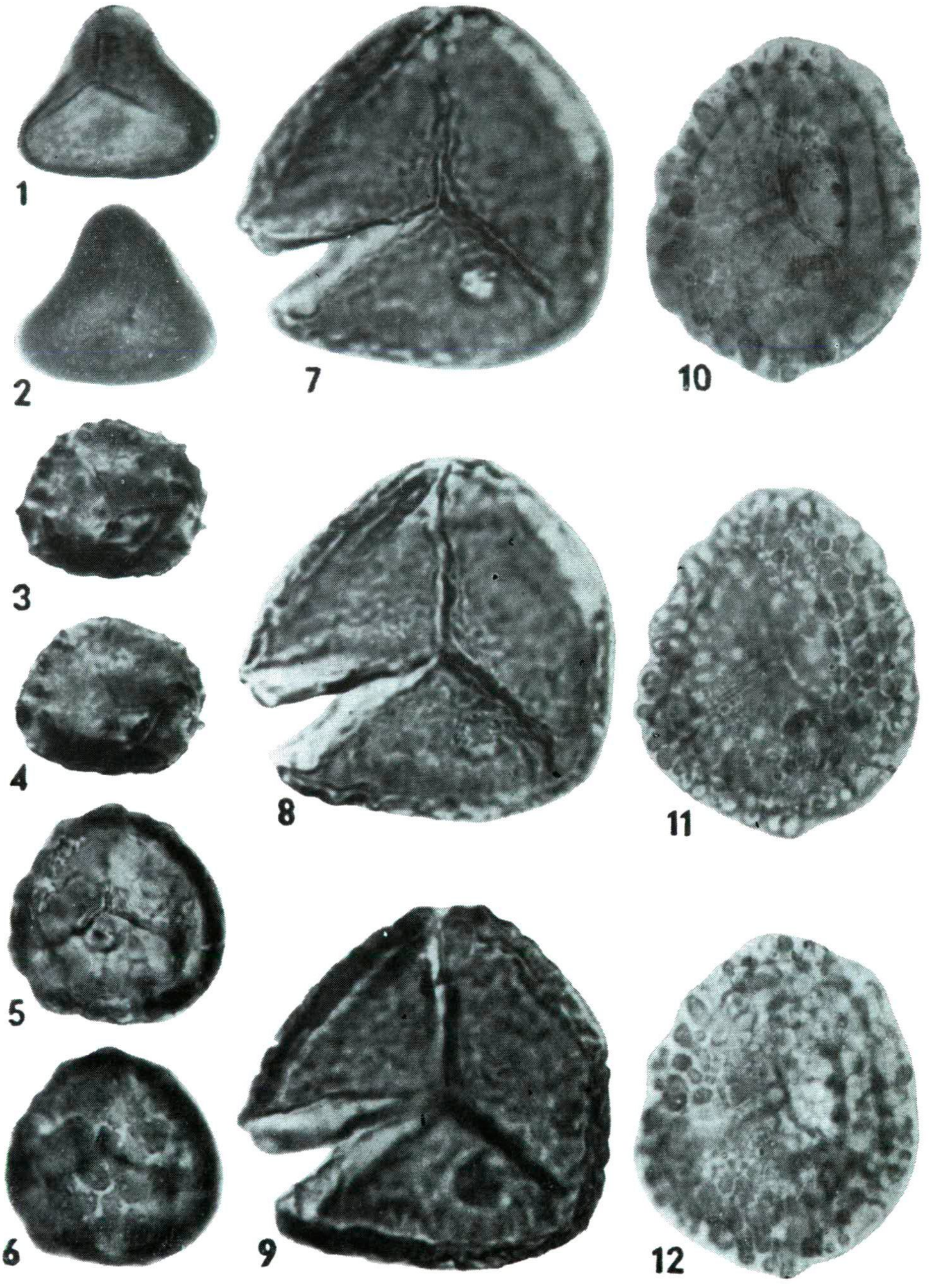
1. *Cl. clarus* n. fsp. (Plate VIII., 10—12)
2. *Cl. platycapitulus* n. fsp. (Plate IX., 1—4)
3. *Cl. pulcher* n. fsp. (Plate IX., 5, 6)
4. *Cl. microcapitulus* n. fsp. (Plate IX., 7—9)
5. *Cl. minor* n. fsp. (Plate IX., 10, 11)
6. *Cl.* fsp. (Plate IX., 12)

Fgen.: *Clavatisporites* n. fgen.
Fgen. typus: *Clavatisporites clarus* n. fsp. (Plate VIII., 10—12).

Plate VIII.

1, 2. — *Verrucosisporites rarus* n. fsp. (U—III—13—1, 5, 5/66, 5)
3, 4. — *Baculatisporites spinifer* (Thiergart 1949) n. comb. (U—III—2—1, 14,5/96,2)
5, 6. — *Trilites pulcher* n. fsp. (U—III—2—1, 16, 5/96)
7—9. — *Trilites couperi* n. fsp. (U—III—6—30)
10—12. — *Clavatisporites clarus* n. fgen. et fsp. (U—III—3—1)
1000×

Plate VIII.



Diagnosis:

Azonotrilet microspores. The sculpture of exosporium is uniformly clavat.

Notes. — It may be well distinguished by the uniformly clavat sculpture from the spores of similar morphology.

The spores enumerated below belong probably to this form genus:

a) KARA—MURZA [1960]: *Selaginella rotundiformis* K.—M.; surroundings of Katangsk, Middle Jurassic period.
b) KURNOSOVA [1960]: *Selaginella fibula* KURNOSOVA 1960 (Plate 7, 2); surroundings of Krasnoyarsk, Cenomanian—Turonian stage.
c) STANLEY and POCOCK [1962]: *Lycopodiumsporites gristhorpensis* COUPER 1958, Western Canada Plains, Jurassic—Createceous period.

1. *Clavatisporites clarus* n. fsp. (Plate VIII., 10—12)

Diagnosis:

Seen from the pole the contour is a triangle with rounded off angles, sometimes it is elliptic or nearly circular. The exosporium is thin, less than 1 μ. The clavat ornamental elements densely cover the surface of the spore at the proximale pole, except next to the laesures. The measure of the ornamental elements is larger at the distale pole than at the proximale one. Their height is 4—6 μ, diameter of the head is 1—5 μ, mostly 3 μ. The shaft is 1—1,5 μ long. The laesures reach the equator.

Maximal measurement: 50 μ.

Holotypus: Plate VIII., 10—12, prep. U—III—3—1.

Locus typicus: Úrkút, manganese mine, carbonate manganese ore mother-lode of the shaft III.

Stratum typicum: Green, grey, finely streaked manganese ore with carbonate content.

Derivatio nominis: from the light exine of the holotype.

2. *Clavatisporites platycapitulus* n. fsp. Plate IX., 1—4)

Diagnosis:

Seen from the pole the contour is almost circular. The exosporium is thin, at most 1 μ thick. The laesures are long, thin and they reach the equator. The clavae are generally 4 μ long, the heads are of different measures: 2—7 μ. At the proximale side the ornamental elements are more sparse, at the distale side they are dense and the heads of the clavae are larger.

Maximal measurement: 36 μ.

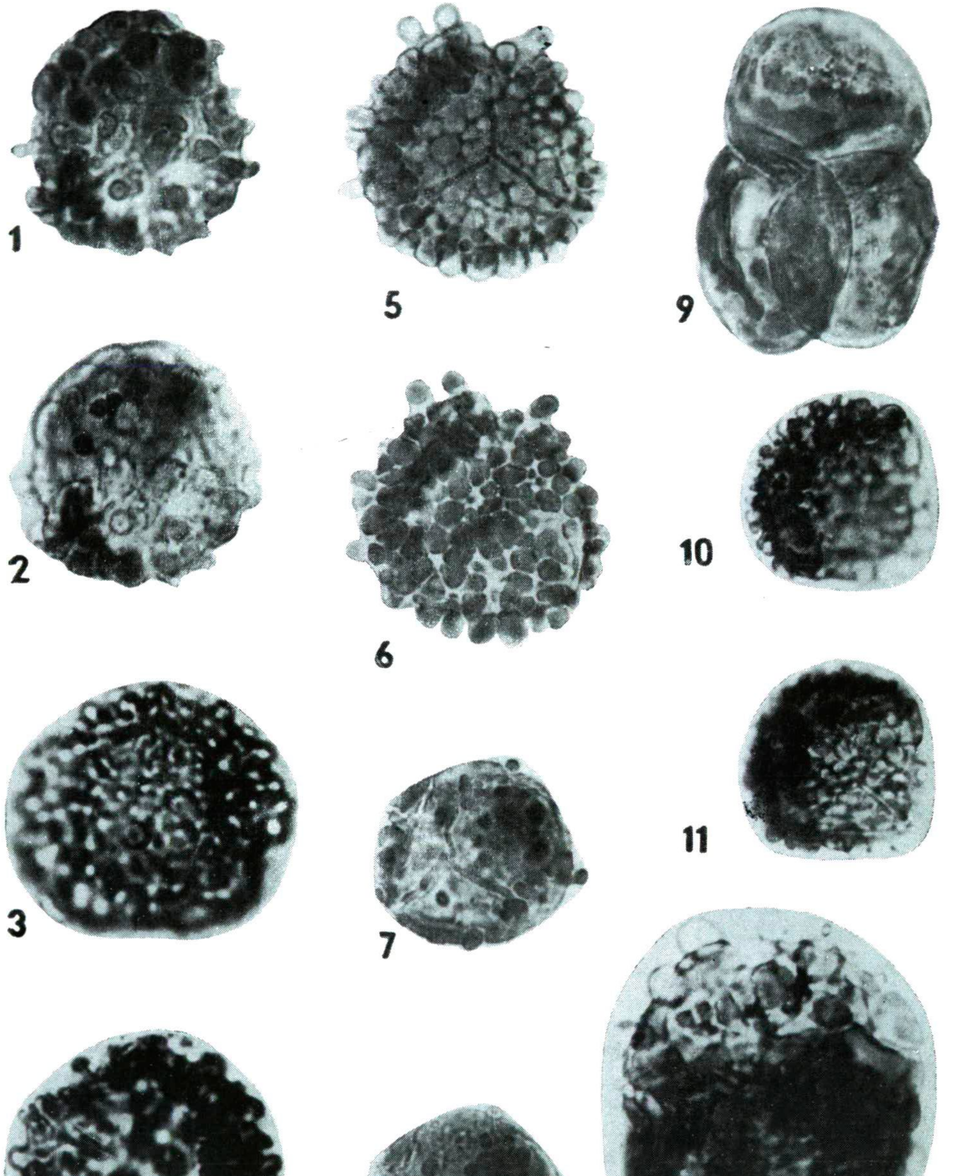
Holotypus: Plate IX., 1, 2, prep. U—III—2—121—5.

Locus typicus: Úrkút, manganese mine, carbonate manganese ore mother-lode of the shaft III.

Plate IX.

1, 2. — *Clavatisporites platycapitulus* n. fgen. et fsp. (U—III—2—121—5)
3, 4. — *Clavatisporites platycapitulus* n. fgen. et n. fsp. (U—III—4—1, 9, 4)
5, 6. — *Clavatisporites pulcher* n. fgen. et fsp. (U—III—4—19)
7, 8. — *Clavatisporites microcapitulus* n. fgen. et fsp. (U—III—4—18)
9. — *Clavatisporites microcapitulus* n. fgen. et fsp. (U—III—4—25)
10, 11. — *Clavatisporites minor* n. fgen. et fsp. (U—III—6—1, 1, 5/74)
12. — *Clavatisporites* fsp. (U—III—2—1, 18/102, 5)
1000×

Plate IX.



Stratum typicum: Dark-grey, finely streaked clayey marl with manganese carbonate content.

Derivatio nominis: from the wide heads of the clavae.

3. *Clavatisporites pulcher* n. fsp. (Plate IX., 5, 6)

Diagnosis:

Seen from the pole the contour is a considerable rounded off triangle. The side lines of the spore are convex. The peaks are sometimes slightly pointed. At the proximale pole the surrounding of the tetrad mark is without any ornaments. Seen from the pole only surrounding of the equatorial contour is covered with clavae in a 4 μ wide zone. The laesures of the tetrad mark are straight, well developped and they reach almost the equatorial contour, $r={}^4/_5$. The distale pole is densely covered with ornamental elements. The heads of the clavae are globose, sometimes they are angularly pressed, their diameter is 1—4—5 μ, mostly 3,5 μ.

Maximal measurement 41 μ.

Holotypus: Plate IX., 5, 6, prep. U—III—4—19.

Locus typicus: Úrkút, manganese mine, carbonate manganese ore mother-lode of the shaft III.

Stratum typicum: Green, grey, finely streaked manganese ore with carbonate content.

Derivatio nominis: from the regular ornaments of the distale pole.

4. *Clavatisporites microcapitulus* n. fsp. (Plate IX, 7—9)

Diagnosis:

Seen from the pole the contour is circular. The exosporium is thin, it is always less than 1 μ. The clavae on the surface of the spore are sparsely dispersed. The haeds are 3 μ diameter in maximal measurement. The laesures of the tetrad mark are sometimes slightly wavy and do not always reach the equatorial contour, $r={}^4/_5$—${}^5/_5$.

Maximal measurement: 28 μ.

Holotypus: Plate IX., 7, 8, prep. U—III—4—18.

Locus typicus: Úrkút, manganese mine, carbonate manganese ore mother-lode of the shaft III.

Stratum typicum: Green, grey, finely streaked manganese ore with carbonate content.

Derivatio nominis: from the relative small heads of the ornamental elements.

5. *Clavatisporites minor* n. fsp. (Plate IX., 10, 11)

Diagnosis:

Seen from the pole the contour is rounded off. The thickness of the exosporium is 1 μ. The ornaments are 3 μ high, the heads of the clavae are 1—3 μ in diameter, the most frequently 2 μ. The laesures of the tetrad mark are straight and they reach almost the equatorial contour, $r={}^4/_5$.

Maximal measurement: 30 μ.

Holotypus: Plate IX., 10, 11, prep. U—III—6—1, 1, 5/74.

Locus typicus: Úrkút, manganese mine, carbonate manganese ore mother-lode of the shaft III.

Stratum typicum: Green, grey, finely streaked manganese ore with carbonate content.

Derivatio nominis: from the small measure.

6. *Clavatisporites* fsp. (Plate IX., 12).

The heads of the sculpture elements are sometimes very large, maximal measure 6 μ. This characteristic distinguishes exactly this form-species, from the other ones. Sorry, the exemplares observed are very corroded and among others the characteristics of the laesures are not to be recognise. Therefore at present we can not give the exact description of this spores.

Fgen.: DICTYOTRILETES (NAUMOVA 1937) R. POT. and KR. 1954
Subfgen.: DICTYOTRILETES (KLUKISPORITES COUPER 1958) STANLEY and POCOCK 1962.

1. *D. (Klukisporites) deaki* n. fsp. (Plate X., 1, 2).
2. *D. (Klukisporites) variegatus* (COUPER 1958) n. comb. (Plate X., 3–6)

Notes. — These spores according to COUPER [1958] belong to the genus *Klukisporites* COUPER 1958. STANLEY and POCOCK [1962] however demonstrated that the genus *Klukisporites* COUPER 1958 is the synonym of *Dictyotriletes* (NAUMOVA 1937) R. POT. and KR. 1954. They publicated one spore fsp. of COUPER [1958] as *Dictyotriletes (Klukisporites) pseudoreticulatus* (COUPER) STANLEY and POCOCK 1962. So they removed as subform-genus from the form-genus *Dictyotriletes* (NAUMOVA 1937) R. POT. and KR. 1954 the spores which were similar to the spores prepared from Klukia megafossilia. This method is followed by us too. *Ischiosporites* BALME 1957 described by BALME [1957] is similar to or identical with this subform-genus.

BOLKHOVITINA [1961] arranged the genus *Klukia* RACIBORSKI 1890 into the familia *Schizaeaceae*. On the basis of the work of COUPER [1958] she published the *Klukisporites visiblis* (BOLKH.) BOLKH. — (syn.: *Stenozonotriletes visiblis* BOLKH. 1953). She denoted the stratigraphical distribution of the spores belonging to the form-genus *Klukisporites* COUPER as the Middle and Upper Jurassic and Lower Cretaceous period.

To this type belongs probably the spore published by KURNOSOVA (1960) from the Upper Jurassic layers of Krasnoyarsk named *Brochotriletes* NAUM. (Plate 5., 15).

1. *Dictyotriletes (Klukisporites) deaki* n. fsp. (Plate X., 1, 2)

Diagnosis:

Seen from the pole the contour is triangular with rounded off angles and convex side lines. The thickness of the exosprium extends to 2,5 μ. The ectexosporium is more thick than the endexosporium. Near to the tetrad mark the surface is smooth or finely scabrat. The laesures do not always reach the equatorial contour, $r = {}^{4}/_{5}$—${}^{5}/_{5}$. Maximal diameter of the area surrounded by the sculptural elements is about 10—14 μ. Seen from above the width of the sculptural elements is about 2,5 μ.

Maximal measurement: 58 μ.

Holotypus: Plate X., 1, 2, prep. U—III—3—1.

Locus typicus: Úrkút, manganes mine, carbonate manganese ore motherlode of the shaft III.

Stratum typicum: Green, grey, finely streaked manganese ore with carbonate content.

Derivatio nominis: from DR. M. H. DEÁK, the excellent investigator of Hungarian mesozoic sporomorphs.

Notes. — The measure of the sculptural elements and the structure of the reticulum distinguish it from *Dictyotriletes (Klukisporites) variegatus* (COUPER 1958) n. comb.

2. *Dictyotriletes (Klukisporites) variegatus* (COUPER 1958) n. comb. (Plate X., 3—6)

Seen from the pole the contour is triangular with rounded off angles and straight or convex slides. At the proximal pole the laesures of the tetrad mark reach almost the equator. Along the laesures there is a 3—4 μ wide torus. The average width of the exosporium is 3,8 μ, the ectexosporium is more thick, than the endexosporium. Seen from above the sculptural elements of the distale pole are 3—4 μ wide in average and they surround a 6—8 μ large irregularly formed area. The maximal measurement of the exemplares observed is 68—88 μ.

According to COUPER [1958] this spore is characteristic on the Middle Jurassic sediments. SAAD [1963] published it as *Klukisporites variegatus* COUPER from the Bajocian sediments of the Middle Jurassic period of Euone Moussa, (a district West of Sinai).

In connection with the spores previously discussed in detail the following summarized evaluation may be given:

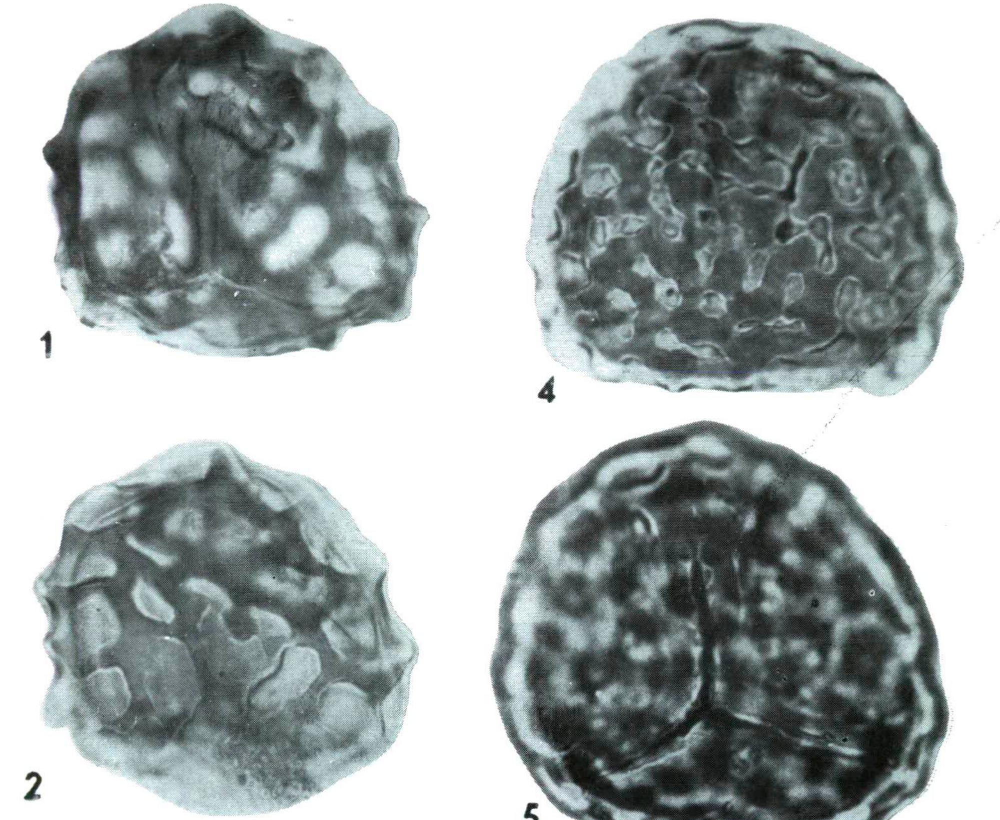
1. In this work 46 spores were discussed in detail. 1 new form-genus and 34 new form-species were described. As new combinations 5 form-species and other 6 form-species previously described were established. 1 spore type was not closer determined due to its incomplete morphology. In authors' previous works only 17 spore types were described and so this work considerably enriched the knowledge of the spore-pollen complex of the Hungarian Jurassic sediments.

2. In the course of the discussion of the taxa 58 forms of similar morphology were mentioned: 9 from the Triassic, 39 from the Jurassic, and 11 from the Cretaceous period. According to the data of the literature the basic type of the Jurassic spore-pollen complexes, known from the sediments of the same age of Eurasia (including the arctic area of the USSR), Ceylon, Pakistan, North-Africa, Egypt and Canada, are similar to each other in many properties. Consequently the Jurassic vegetation was also similar in the identical stages. Naturally, this similarity does not mean a complete identity of the species on these remote areas. There is a possibility, however, to parallelize the Jurassic sediments of remote areas with the aid of palynological methods. As the best

Plate X.

1, 2. — *Dictyotriletes (Klukisporites) deaki* n. fsp. (U—III—3—1)
3, 4. — *Dictyotriletes (Klukisporites) variegatus* (COUPER 1958) n. comb. (U—III—2—59)
5, 6. — *Dictyotriletes (Klukisporites) variegatus* (COUPER 1958) n. comb.
1000×

Plate X.



example may be mentioned the latest results of SAAD [1963] about the Jurassic spore-pollen complexes of Egypt.

3. According to authors' own investigations and the data of the literature, the most wide-spread spore types stratigraphically arranged are the followings:

A) In the sediments of the Triassic and the Lower Jurassic period a very frequent type is:

Toroisporis (Toroisporis) toralis (LESCHIK 1955) n. comb.

B) Characteristic in first line to the Jurassic sediments are:

Leiotriletes manganicus n. fsp.

Toroisporis (Toroisporis) curvitorus n. fsp.

Verrucosisporites rarus n. fsp.

C) In the Jurassic and Cretaceous periods frequent types are:

Leiotriletes sphagnoides n. fsp.

Concavisporites (Obtusisporis) kara-murzae n. fsp.

Clavatisporites n. fgen.

D) In the sediments of Triassic, Jurassic and Creataceous periods equally frequent types are:

Leiotriletes urkutensis n. fsp.

Punctatisporites rotundus n. fsp.

4. The data of the two previous points put the establishments about the age of the manganese ore mother-lode of Úrkút in a new light. The types occuring equally in the Triassic, Jurassic and Cretaceous periods are summarized in the followings:

Trias	Jura	Creta	
9	38	11	(all the literary data)
1	3	3	(especially wide-spread spore types)

These results do not support the Upper Liassic origin of the manganese carbonate ore mother-lode. On the basis of the abovementioned data it may be supposed more probably the origin from the Middle or Upper Jurassic period, because the types from the Cretaceous period are more numerous that the types from the Triassic period. This is not the final establishment of the authors. For this purpose it must first eveluate all of the new palynological data. On the basis of the data till now the manganese ore seems younger than the Upper Liassic period, most probably in the Bajocian stage. This establishment is supported by the palynological data of the hard coal from the Lower Liassic period of Komló. In connection with this the forms of similar types from Komló and Úrkút are to be mentioned. These forms are either of „older" types (e. g. *Toroisporis [Toroisporis] toralis* [LESCHIK 1955] n. comb.) or definitely Jurassic ones. On the other hand, it is very important, that BÓNA [1963] found the form species *Zebrasporites* KLAUS 1960 in the carboniferous Liassic layers of Komló, which form-genus was first described from layers of the Carnian stage. According to the investigations of SCHULZ [1962] in Thüringia the spores of this form genus are characteristic in the Rhätian-Liassic border, especially in the Rhätian stage, but they occur in the lowest layer of the Liassic period (Lias α_1) too. This also support the Lower Liassic origin of the hard coal of Komló. In addition to this, forms of more modern types

(e. g. *Dictyotriletes [Klukisporites] variegatus* [COUPER 1958] n. comb.) are lacking in the spore-pollen complexes of the carboniferous layers of Komló. So the two Liassic formation may be well distinguished on palynological basis. A detailed stratigraphical palynology of the Lower Liassic period of Komló and the presumed Upper Liassic period of Úrkút may be not yet given because of the lack of a complete modern palynological analysis of these complexes.

In connection with the quantitative results of the palynological investigations the followings are to be mentioned (Figure 1.):

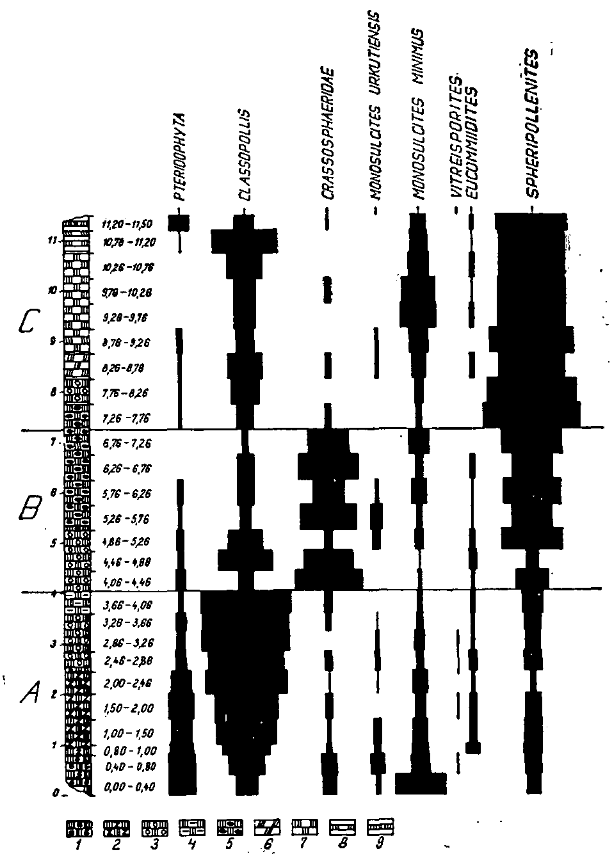


Figure 1.

Drawing of the profil investigated with the diagram of spores and pollens. A = *Classopollis-level,* B = *Crassosphaeridae-level,* C = *Spheripollenites-level.* 1 = dark grey, finely streaked clayey marl with manganese carbonate, 2 = green, grey, finely streaked carbonate manganese ore, 3 = brownish green, greenish brown, browns and finely streaked carbonate manganese ore, 4 = brown, light brown, finely streaked carbonate manganese ore, 5 = black, brownish black, light brown, finely streaked carbonate manganese ore, 6 = brownish red, locally roughly streaked carbonate manganese ore, 7 = green, greenish brown, light green, grey, roughly streaked carbonate manganese ore, 8 = grey, rhodochrozit and pyrit containing carbonate manganese ore, 9 = grey, radiolaria containing clayey marl with manganese containing streaks.

From the point of view of stratigraphical division of the profil of the manganese carbonate mother-lode the taxa *Classopollis* PFLUG 1953, *Crassosphaeridae* and *Spheripollenites* COUPER 1958 are of greatest importance. Further, it may be taken into consideration the total number of *Pteridophyta* spores and the changes of the quantity of *Monosulcites minimus* COOKSON 1947. Some other taxa are also represented on the Figure (*Monosulcites urkutensis* SIMONCSICS and KEDVES 1961, *Vitreisporites* fsp., *Eucommiidites* fsp.), but their stratigraphical significance is unimportant. The forms belonging to the form genus *Vitreisporites* are not to be considered as level-indicators, because of their sporadic occurrence in the lower third of the bed. A short characterization of the three levels of the carbonate manganese ore distinguished with the aid of palynological method is given as follows:

A) *Classopollis-level* (Figure 1. A)

It is characterized by the dominancy or high quantity of the pollens of the form genus *Classopollis* PFLUG 1963 and the relative high per cent and form-abundance of *Pteridophyta* spores.

B) *Crassosphaeridae-level* (Figure 1. B)

It is fairly distinguished from the former level by the dominancy or at least high per cent of spores belonging to the different genera and species of the different genera and species of the familia *Crassosphaeridae*. The dominancy of the pollens of the form genus *Classopollis* come to an end and the quantity of the *Pteridophyta* spores diminishes to a minimum.

C) *Spheripollenites-level* (Figure 1. C)

The pollens of the form species of the form genus *Spheripollenites* are dominant. *Monosulcites minimus* COOKSON 1947 and *Classopollis* PFLUG 1953 occur locally in higher per cent. Occurrence of *Crassospaeridae* is sporadic.

The possibility of the reconstruction of the levels characterized above i. e. the practical use is proved by the possibility of the parallelization with the spore complexes established in the course of former investigations of the authors [1961] on the manganese ore of Úrkút. The following palynological characteristics are to be emphasized in connection with the samples 33 „a" and 35 „b", which are also accessible to a quantitative evaluation:

1. The dominancy of the pollens belonging to the form-genus *Spheripollenites*.

2. The comparatively high quantity of *Monosulcites minimus* COOKSON 1947, in the lower sample 35 "b" with a relatively high content of the pollens *Classopollis*.

3. Few *Pteridophyta* spores.

4. Quantity of *Crassosphaeridae* is minimal. It is not represented on the diagram, it is mentioned only among the qualitative results.

These palynological characteristics are identical with the „C", *Spheripollenites* level of the fundamental profil. Taking into consideration the regular changes of quantity of *Monosulcites minimus* COOKSON 1947 inside the "C"-level, the samples 33 "a" and 35 "b" mentioned above may be identified more exactly with the middle part of the upper, "C"-level. According to this the idea arises, that inside the three level established, further sublevels might be distinguished. e. g. In the case of the level "C" three sublevels may be distinguished and similar possibilities may be supposed in the case of the other levels. This further distinctions, however, are considered by the authors as unnecessary, all the more because it is uncertain, that the identification of the sublevels will be so easy in all cases as in this one.

As shown above, the levels of the carbonate manganese ore were established on palynological basis with the aid of two factors:

1. The autochtonous microplanctontic organisms *(Crassosphaeridae)*.
2. The accumulation of autochtonous and allachtonous sporomorphs in the sediments. These latters presented themselves in different composition in the course of the cycle of immersion parallel with the different vegetation types surrounding the basin in which the sediments accumulated. So the basis for the establishment of the levels of the manganese ore were the changes of the biotops and vegetation surrounding the basin. In the course of the formation of the carbonate manganese mother-lode of Úrkút the zonation of the surrounding vegetation may be reconstructed as follows (Figure 2.):

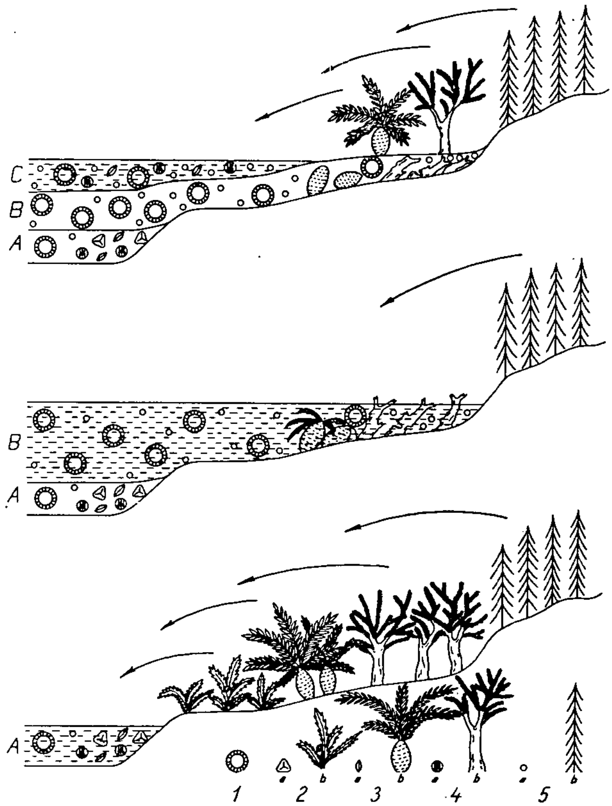


Figure 2.

Schematic reconstruction of the vegetation surrounding the basin in which the manganeous sediments accumulated and the development of the spore-pollen complexes of each levels. 1 = *Crassosphaeridae,* 2 = *Filicinae;* a: spore, b: fern plant, 3 = *Cycadinae;* a: pollen, b: grawn-up plant, 4 = *Classopollis* producing *Coniferae,* a: *Classopollis,* b: *Classopollis* producing plant, 5 = *Spheripollenites* producing *Coniferae,* a: *Spheripollenites,* b: *Spheripollenites* producing plant.

The spore and pollen composition of the level "A" indicates the vicinity of open water vegetation. This is proved by the presence of *Crassosphaeridae* relics. Next to the shores on humid biotops the great quantity of *Filicinae* spores indicates an association with ferns. More remoted followed a level with *Cycadinae* and *Coniferae*. The latters produced the pollens belonging to the form-genus *Classopollis*. The botanical connections of this pollen type are discussed in detail by POCOCK and JANSONIUS [1961]. Their establishments are accepted by the authors too. According to this the plants producing the pollens of *Classopollis* type were extinct *Gymnospermae*. Also some species of *Cheirolepis, Brachyphyllum* and *Pagiophyllum* produced pollens of such a type. One considers these plants as *Coniferae* which lived along the shores but in arid biotops. They lived in the vicinity of fossil *Cycadinae*. Accordingly the *Filicinae* zone was followed by a coenosis containing *Cycadinae, Cheirolepis, Brachyphyllum* and *Pagiophyllum*. According to this reconstruction the process of inundation of the biotops with an arider ecology inside the level "A" may be well explained. The per cent proportion of the pollens belonging to the form-genus *Classopollis* increases and it reaches a maximum in the uppermost part of the level. This is explained by the supposition, that the quickly rising water destroyed the *Filicinae* zone and reached directly the *Classopollis* producing *Coniferae* zone. This process is indicated by the regular changes in the quantity of the *Filicinae* and *Classopollis* pollens. Due to the inundation of the biotop of the *Classopollis* producing *Coniferae* and the destruction of the vegetation, the spores accumulated in the sediments originated already not from the litoral vegetation but they were produced by planctontic organism *(Crassosphaeridae,* level B) and by *Coniferae* living in higher biotops *(Spheripollenites)*. This supposition, i. e. between the biotops of the *Coniferae* producing *Classopollis* and *Spheripollenites* respectively it existed a very considerable ecological difference, is the only acceptable explanation of the sharp palynological border between the levels "A" and "B" and "B" and "C". The *Classopollis* minimum following a *Classopollis* maximum mey be explained only with the supposition that the rising water reached a *Coniferae* zone living on a plain area. At this time accumulated the *Classopollis* pollen in a maximal quantity. After the inundation of the area this vegetation was destructed. So the maximum of the *Classopollis* accumulation diminished to a minimum. Parallel with this the planctontic organism appeared at once in dominant or at least in a very considerable quantity and besides the pollens of plants living on higher biotops *(Spheripollenites)* accumulated in the basin. In the level "B", which may be considered as a devastation level, the situation made possible the fossilization of the stems in the manganese ore layers. In connection with this two related problems are to be mentioned:

1. The botanical connections of the silicified stems.

2. The problem, wether the *Classopollis* producing plants *(Cheirolepis, Brachyphyllum* and *Pagiophyllum)* belong to the *Araucariaceae* or not. The stems from the manganese ore of Úrkút (first investigated by ANDREÁNSZKY [1949]) have an araucaroid structure. In contrast to this ANDREÁNSZKY did not deduced the conclusion (which seems perhaps a logical one), that these stems are in a direct evolutionary connection with the modern Araucariaceae. (Namely, a great part of the mezozoic stems and almost all paleozoic ones are of araucaroid structure.) These stems must be the plants which produced

Classopollis: Cheirolepis, Brachyphyllum and *Pagiophyllum.* This is the opinion of POCOCK and JANSONIUS [1961] too.

On the other hand COUPER [1958] brought the in situ found pollens of *Pagiophyllum connivens* KENDALL and *Cheirolepis münsteri* SCHENK in connection with *Classopollis torosus* (REISSINGER) COUPER on a morphological basis. In contrast to KENDALL as belonging to *Araucariaceae* because of the totally different morphology of the in stiu pollens and the pollens of the recent *Araucariaceae.* The xylem structure of the stems investigated by KENDALL [1952] indicates a relation with the *Araucariaceae.* This property, however, is not a conclusive proof, according to the abovementioned facts. The *Classopollis* type pollen of *Pagiophyllum connivens* KENDALL is inconsistent with the *Araucariaceae* and therefore authors agree with POCOCK and JANSONIUS [1961]. The formation of the level "C", however, might be a shallow moore. The conditions corresponding to the ecological demans of the *Classopollis* producing *Coniferae* are not yet developped. In the sediments accumulated henceforward the pollens of the *Coniferae* living on higher areas *(Spheripollenites).* The rising of the quantity of the *Pteridophyta* spores and *Classopollis* in the upper part of the level indicates the re-establishment of the original ecological conditions.

Summarizing the ideas about the zonation of the vegetation surrounding the basin in which the sediments accumulated, the following coenoses were established:

1. An open vegetation far off the shores with planctontic algae.
2. A *Pteridophyta* coenosis with humid ecology along the shores.
3. A *Coniferae* coenosis with *Cycadinae—Cheirolepis—Brachyphyllum—Pagiophyllum* near the shores with an arid ecology.
4. The *Spheripollites* producing *Coniferae* coenosis which lived on the higher areas.

In the course of the sediment formation authors consider the *Crassosphaeridae* as autochtons, the spores of *Pteridophyta* and the pollens of the form-genera *Classopollis* and *Monosulcites minimus* COOKSON 1947 as sedimental autochtons, because these plants formed the vegetation of the shores and the area near to the shores of the basin. The *Spheripollenites* pollens were considered as allochtons, because the plants producing these pollens lived undoubtedly on higher areas beyond the basin. The proof for this is the following: the per cent values of *Crassosphaeridae* and *Spheripollenites* in the level "B" give a sum which is essentially identical with the quantity of *Spheripollenites* in the level "C", i. e. there is no difference between the levels "B" and "C" considering the pollens occuring in maximal quantity. The sharp border betweeen the two levels may be indicated by the diminishing to a minimum of the autochtonous marine planctontic residues.

SUMMARY

1. Authors' latest investigations on the carbonate manganese mother-lode of Úrkút demonstrated, that in the carbonate ores there are more sporomorphs than in the oxid ores. The qualitative and quantitative data are suitable not only for the determination of the age of the ore but for microstratigraphical purposes too.

2. From the sporomorphs demonstrated in this work 46 spores were discussed in detail. 1 n. fgen., 34 n. fsp. and 5 n. comb. were described. 1 spore type was not closer determined due to the insufficient morphology.

3. On the basis of the qualitative results as the age of the formation of the manganese ore investigated seems younger than the Upper Liassic period.

4. On the fundamental profil of the carbonate manganese ore mother-lode of the shaft III. of Úrkút the levels were distinguished on palynological basis:

A) *Classopollis-level.*

B) *Crassosphaeridae-level.*

C) *Spheripollenites-level.*

5. Suitability these levels for identification of layers was proved by parallelization of the diagram of the fundamental profil with the quantitative data previously published by the authors.

6. Establishment of layers in the manganese ore on a palynological basis was attributed to the zonation of the vegetation surrounding the basin in which the sediments accumulated and to the changes in the microfossilia composition caused by the changes of the vegetation in the time of the formation of the sediments.

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DATA ON FELSŐBÁNYAITE

By S. Koch

Institute for Mineralogy and Petrography of the University at Szeged

I. Sarudi

Institute for Chemistry of the Town Szeged

The felsőbányaite is one of the very rare minerals discovered in Hungary during the middle of the past century (Haidinger, 1853). Owing to its rarity it belongs to the minerals not well known till up to date, even it is denoted in some handbooks as a not well identified, uncertain mineral species.

Its locality — shown by its name too — is Felsőbánya *(Baia Sprie, Roumania)*. To mention Kapnikbánya (Capnic, Roumania) as locality of felsőbányaite is a mistake. The mineral occurred here and taken erroneously as felsőbányaite was really a variety of wawellite named "capnicite" as it was stated already in 1855 by Kenngott [1]. Kapnikbánya as the locality of felsőbányaite is mentioned neither by V. Zepharovich [2] nor by M. Tóth [3]. In the 2nd edition (1864) of J. Szabó's Mineralogy [4] Felsőbánya is mentioned as the locality of felsőbányaite, however, in the 3rd edition (1875) Kapnikbánya and in the 4th one (1893) Felsőbánya and Kapnikbánya are noted as localities of felsőbányaite. The locality is erroneously given also in Hintze's Handbuch der Mineralogie [5] as well as in some Hungarian mineralogical handbooks as e. g. in Mineralogy by Mauritz and Vendl and in Mineralogy by Koch and Sztrókay or in Sztrókay's Determinative Mineralogy.

Felsőbányaite has never occurred in Kapnikbánya only in Felsőbánya could it be found during the middle of the past century as rarity in the oxidation zone of the main lode of the eastern part of the Bányahegy. This was the most beautiful occurrence of this mineral in form of spherulites, 5 mm in diameter grown on thin quartz crust. It could be found also in spherulites of 1—2 mm in size grown on yellowish tabular crystals of baryte and on antimonite crystals of 1—2 cm in length. Specimens of mode of occurrence last mentioned were not at disposal of the authors for investigation.

Since Kenngott's [1], Haidinger's [6] and Hauer's [7] investigations carried out more than a hundred years ago, only Krenner [8] has dealt more detailed with this rare mineral. The material of minute spherulites separated from the thin quartz crust of the most beautiful felsőbányaite specimen was investigated by Krenner [8]. The fire in the Mineral Collection of the Hungarian National Museum in 1956 caused unfortunately the perdition of this specimen too, but the optical data and an excellent drawing of this felsőbányaite specimen remained published by Krenner in his work mentioned above. The chemical composition of felsőbányaite is known only from HAUER's analysis published in 1854 [7] giving also the chemical formula.

One of the authors received in the early years of this century a number of smaller pieces of felsőbányaite as a gift of S. FIZÉLY, one-time manager of the

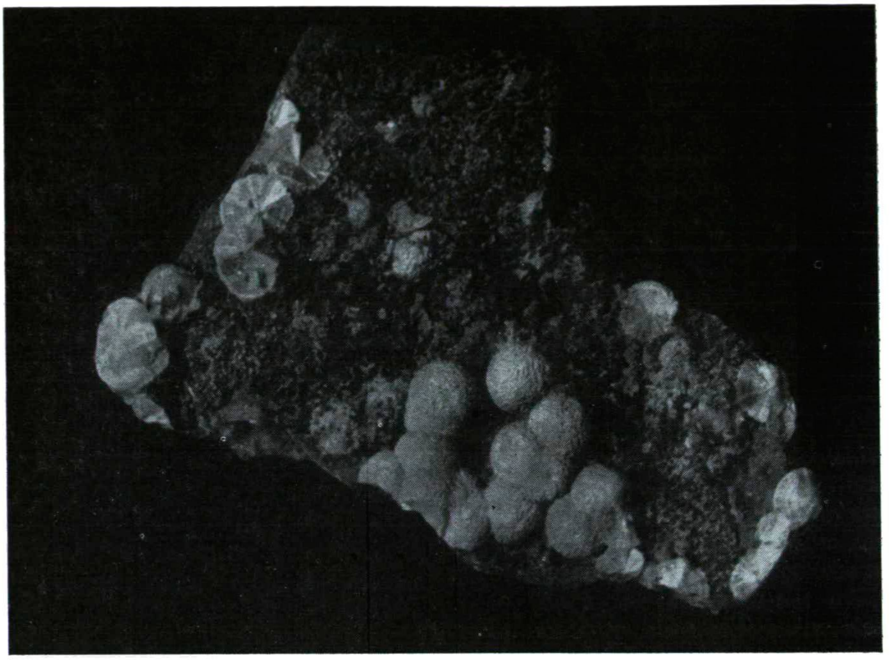

Fig. 1. Globular-radial aggregates of felsőbányaite on quartz crust. 2× natural size.

mine Felsőbánya. These specimens are to day in the Mineral Collection of the Institute for Mineralogy and Petrography of the University at Szeged. The material investigated by the present authors was taken from these specimens of undoubtedly authentic locality.

The spherulites are aggregates of concentrically arranged thin tabular crystals. The surface of the spherulites is covered with a weathered, whitish coloured layer of 0,5 mm in thickness. The platelets have rhombic holohedral habit. The platelets are colourless, having a vitreous luster. The dominating planes of (001) are terminated by narrow planes of (hkl). The cleavage is perfect according to the plane of 001 but cleavage can also be observed according to the planes 100 and 010, respectively. These three cleavage directions are perpendicular to each other, the extinction is straight. The plane of optical axes is parallel to the longitudinal axis of the platelets. Birefringence is +. Specific gravity of selected crystals is 2,35.

The result of the analysis is as follows:

Al_2O_3	37,27%
SO_3	14,50
H_2O	31,53
Fe_2O_3	1,49
SiO_2	15,13
	99,92%

Subtracting the impurities:

Al_2O_3	44,70%
SO_3	17,39
H_2O	37,82
	99,91%

TABLE 1

X-RAY POWDER SPACINGS FOR FELSŐBÁNYAITE FROM FELSŐBÁNYA

Cu -K_α RADIATION, NI FILTER, CAMERA RADIUS 57,3 mm

No.	d_{kX}	I/I_0	No.	d_{kX}	I/I_0
1	5,95	3	19	1,67	0,5
2	5,32	2	20	1,62	3
3	4,78	10	21	1,54	0,5
4	4,63	10	22	1,45	2
5	3,85	1	23	1,43	3
6	3,66	4	24	1,38	1
7	3,39	2	25	1,34	0,5
8	2,92	1	26	1,30	0,5
9	2,87	1	27	1,22	0,5
10	2,70	4	28	1,18	0,8
11	2,45	4	29	1,10	0,5
12	2,27	5	30	1,07	1
13	2,19	3	31	0,919	0,5
14	2,07	1	32	0,899	0,5
15	1,96	1	33	0,861	0,5
16	1,89	3	34	0,840	0,6
17	1,83	1	35	0,821	0,5
18	1,76	2			

The formula calculated from the data of analysis is:

$$Al_4(SO_4)\cdot(OH)_{10}\cdot 5\,H_2O.$$

Dipl. Ing. JAROSLAV BAUER (Prague) was so kind to carry out the X-ray investigation of selected felsőbányaite. The data are summarised in Table 1. The authors express their gratitude to Mr. Dipl. Ing. J. BAUER for his kindness.

On the basis of the investigations mentioned above — in accordance with the results of the older investigations — the felsőbányaite has a definite composition and it can not be considered as an uncertain mineral species.

Fig. 2. Globular-radial aggregates of felsőbányaite. 2× natural size.

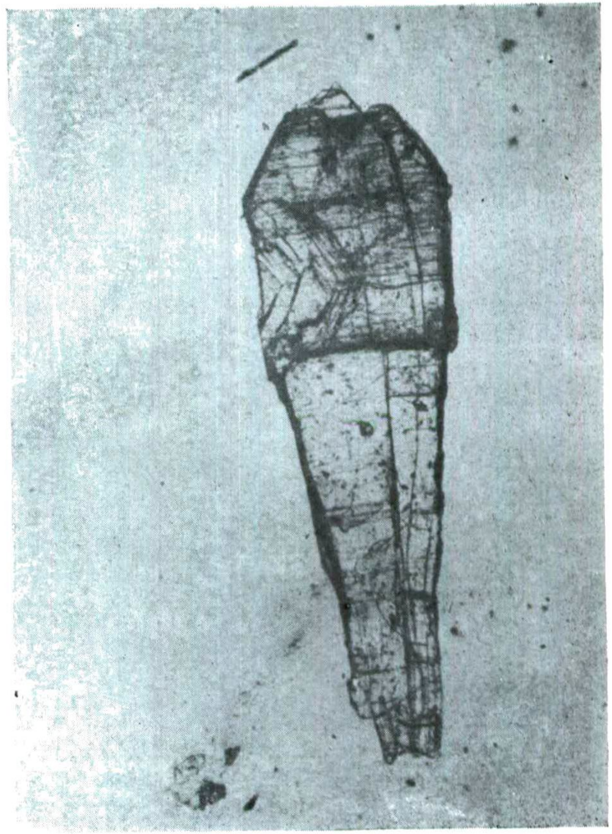

Fig. 3. Crystal of felsőbányaite with two cleavage directions. Magnif. 25×.

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OXYANDESITIC PETROFACIES IN THE WESTERN AND CENTRAL PARTS OF THE MÁTRA MOUNTAINS

By

J. MEZŐSI

Institute for Mineralogy and Petrography of the University at Szeged

INTRODUCTION

In young volcanic territories, more or less altered rocks occur very frequently. During the mapping of such rocks one meets with some difficulties, on the one hand because of the insufficiency of available data, on the other hand because of the great variety of alterations, the right interpretation of the latter being problematical, too. These rocks have been referred to as „hydrothermally altered rocks", and chiefly observed in ore districts. Clearing up of genetic relationship between variosuly altered rocks and „fresh rock" was lacking, too.

SZÁDECZKY-KARDOSS, examining the fundamental problems of volcanic mountains [11, 12], studied the genetical processes of the rocks hitherto considered as „hydrothermally" altered, and has established the system of altered rocks. Starting from the general regularities of hypomagmatites and metamagmatites, the formation, appearance, mineral composition of each type of altered rocks is easily interpretable in the above-mentioned system.

As it is well-known, the temperature of crystallization of hypomagmatites is 1200 to 50° C, their volatile-content may be considerable. These rocks are characterized by the presence of primary low temperature minerals rich in volatiles (clay-minerals, chlorite, etc.), and they are formed in a hygroscopic environment. In the case of metamagmatites, a partial substitution by volatiles takes place. Inside the magmatic mass, they chiefly appear along irregularly ramifying zones around tectonic lines. The great majority of epigenetically altered magmatic rocks belongs to this group: oxyvolcanites, hydrovolcanites, chlorovolcanites, etc. Oxyvolcanites may occur among hypomagmatites and metamagmatites, too.

FORMATION OF OXYANDESITES

After SZÁDECZKY-KARDOSS, the characteristic features of the different types of altered rocks have been described by PANTÓ [8]. As for the oxyvolcanites, PANTÓ has pointed out that they always represented rock-alterations taking place in oxidizing environment. In order to establish a uniform interpretation, the products of both endometamagmatic and exometamagmatic processes are classed here. Great bodies of oxyandesites are not frequent. Metaoxyandesites of irregular shape and smaller mass are more wide-spread. Though the mapping of the latter — because of their small size — meets with difficulties, it is necessary to examine them from both volcanological and tectonical points of view.

It is difficult to give the liminal value of oxyvolcanites. The red colour of the rock is not always proportional to the O_{Fe} value. It is proved by serial examinations carried out on rocks of the Mátra Mountains, that it is impossible to unequivocally infer the degree of oxidation from the increase of O_{Fe}. Previously, PANTÓ, examining the andesites of Tokaj-Hegyalja [8], has pointed out that the reddish brown colour of the rock depended first of all on the respective modification and fine texture development of Fe_2O_3.

In igneous rocks $Fe^{2+} > Fe^{3+}$, in sediments it is the very reverse. The same holds true of oxyvolcanites. Considering the degree of oxidation, it is 1,4—1,6 $\left(\frac{2\ Fe_2O_3}{FeO}\right)$ the same value being higher than 5,0 in the case of oxyvolcanites. It would not be right, however, to characterize oxyandesites merely by the higher degree of oxidation, since this higher degree of oxidation does not always imply the distinct red or reddish brown colouration of the rock, whereas, in the field, oxyandesites are mostly recognized by colour.

To give a good example of the fact that the increase of the degree of oxidation does not necessarily imply the red colouration of the rock, we mention the rock of the andesite-quarry of the entrance of the Csevice valley at Tar; this rock belongs to a Lower Helvetian series. In its fresh state, this rock is dark grey, compact. At the fissures, the rock is partly altered by infiltrating waters: limonite occurs very frequently along the fissures, and it is forming incrustations or filling up thin fissures. As pyritic, quartzy veins are to be found in the rock, too, not only exometamagmatic but also endometamagmatic alteration should be present. Pseudoagglomerate formations, appearing here and there, show the same. Thus ferric iron does not precipitate, here, in the form of haematite, but in that of limonite, which generally does not take part in the colouration of the whole rock. Colouration produced by limonite is limited to the fissures.

It is well-known that, under subaerial conditions, when p_H is 4 to 8, iron precipitates in the form of $Fe(OH)_3$, wherefrom limonitic minerals are formed. Therefore, in this case, the colouration of the rock can undergo the effect of limonite minerals formed in the course of diagenesis. Upon the effect of hydrothermal solutions or higher temperature, ferrous iron can turn into ferric iron, at similar p_H in case of medium oxidation-reduction potential, therefore it is very difficult to distinguish oxyvolcanites produced by hydrothermal processes from those produced by weathering [11].

At this occurrence, the following data have been given by the analyses. 1 = weight percents of the fresh rock, 2 = weight percents of the altered rock. Analyst: L. JANKOVICH)

	1.	2.
SiO_2	46,92%	49,97%
TiO_2	0,63	1,17
Al_2O_3	21,18	17,07
Fe_2O_3	0,12	6,50
FeO	4,94	1,30
MnO	0,34	—
MgO	2,07	1,64
CaO	13,80	4,30
Na_2O	2,11	1,27
K_2O	0,95	0,75
H_2O^+	6,29	14,88
H_2O^-	0,14	0,46
CO_2	0,36	0,62
P_2O_5	0,16	0,59
	100,01%	100,52%

There is a considerable difference between the respective degrees of oxidation. In the fresh rock, the value of O_{Fe} is as low as 0,05 which indicates that consolidation did not take place on the surface, but near the surface where conditions of oxidation did not exist. Consolidation taking place near the surface is also indicated by the amount of the groundmass which is much smaller than in the neighbouring andesites, while its degree of crystallization is higher.

The difference between the values of Al_2O_3 is conspicuous pointing to the fact that weathering took place at higher p_H, thus it might have been at least partly eliminated in solution. The appearance of calcite indicates higher value of p_H too.

Examining the possibilities of oxyvolcanite formation, SZÁDECZKY-KARDOSS [13] has come to the conclusion that, in case of lower oxidation-reduction potential, at p_H 6 to 8, orthovolcanites are stable, while opacitization appears at increasing values of oxidation-reduction potential (+0,2 to O,3 V). In the latter case, the degree of oxidation will be considerably higher, moreover, in the case of oxyvolcanites the value of oxidation-reduction potential is as high as +1,0 V. In case of higher water-content, in similar conditions as for the rest, it is leucovolcanite which will be stable. The formation of oxyvolcanites is considerably affected by p_H, since in case of higher p_H it is montmorillonitization, at lower p_H it is kaolinization which can be observed. In these cases, of course, the volatile-content should be higher, too.

After all, in the field work we can subscribe to PANTÓ's opinion, according to whom *„oxyvolcanite"* is a collective term for rocks, the alteration of which characteristically produces Fe_2O_3 minerals. This phenomenon becomes visible in the colour of the rock: various nuances of red are observable, even macroscopically. As a matter of course, the degree of oxidation of these rocks will be higher, often as high as 8 or 10.

FORMS OF Fe_2O_3 AND Fe_3O_4

Now, one can raise the question in what form Fe_2O_3 is present. Many varieties have been described. Two forms certainly exist, namely α-Fe_2O_3 *i. e.*

haematite and γ-Fe_2O_3 *i. e. maghemite.* Both forms may be considered as polymorphic modifications of the Fe_2O_3 compound. According to the examination it is quite probable that modification α is stable, while γ is the metastable one. MASON [6] refers to several authors according to whom modification α turns to modification γ in the interval of 200 to 700 (800)° C. This interval depends on the conditions of formation of the mineral in question, on the impurities, etc. Modification γ turns into modification α by increase in temperature. As, at ordinary temperature, the turning of modification γ to modification α is slow, the former one occurs in nature, too. Natural γ-Fe_2O_3, *i. e.* maghemite is probably produced in the oxidation zone.

Martite also shows the Fe_2O_3 composition, but this is pseudomorphous after magnetite. Martitization always follows crystallographical directions; mostly along octahedral faces, whereas conversion to maghemite is independent from any crystallographic form.

GRUNER [3] has pointed out that magnetite was very slowly oxidizing into haematite, in the open air, at 150 to 200° C. Oxidation starts along the octahedral faces, as well as it has been observed in the case of martitization. In accordance with the above-mentioned phenomenon, natural turning of magnetite into haematite takes place near the surface of the Earth, exclusively in the oxidation zone. This process is a sort of weathering. According to SHEPERD [9] the volatiles of the lavas and magmatic rocks always contain reducing agents (H_2, CO, SO_2, etc.), thus the effect of magmatic fluidal solutions on Fe_2O_3 may be expressed by following equations:

$$3\ Fe_2O_3 + CO = 2\ Fe_3O_4 + CO_2$$
$$3\ Fe_2O_3 + H_2 = 2\ Fe_3O_4 + H_2O$$

It has been proved by experimental evidence that, in this reactions, equilibrium shifted to the right to such a degree that these processes might be practically considered as irreversible. The equations also show that one weight fraction of CO can reduce seventeen times as much haematite to magnetite, while H_2 reduces 240 times as much. This is why primary haematite lacking or playing a minor part in magmatic rocks, except for granite.

SO_2 and less oxidized sulfur compounds reduce ferric iron at a relatively low temperature, this effect is reflected by the presence of magnetite in some sulfide deposits. It can be stated, therefore, that haematite turns into magnetite on the effect of reducing agents, at least a considerable part of the transformation haematite/magnetite is due to the reducing effect of C, H and S-compounds, the source of which can be a magmatic one.

The alteration of magnetite into haematite is a general and wide-spread phenomenon. It follows from the foregoing that magnetite cannot turn into haematite but in case of absence of reducing agents or in conditions favourable to oxidation.

Magnetite can turn into haematite, as a result of descendent processes. The p_H of the medium in which the reaction takes place, plays an important part in the oxidation of ferrous iron into ferric iron. Oxidation takes place much more easily in an alkaline medium than in a neutral or acidic one. It is quite probable that alkaline solutions, even in the absence of atmospheric oxygen, have an oxidizing effect on magnetite [11]. Chemical factors in themselves, however, cannot completely determine the degree of replacement.

Physical properties of the rock, porosity, grain-size, direction of the fissures are factors promoting the change or retarding it. The change of haematite into magnetite implies decrease in volume, while the turning of magnetite into haematite is accompanied by increase in volume. This is the result of the difference between specific gravities calculated from the accepted unit-cell dimensions of magnetite and haematite. In the case of magnetite and haematite, there is an increase of 2,5 percent in the respective volumes.

According to SCHMIDT and VERMAAS [10], there are two, distinctly exothermal peaks on the d. t. a. curve of magnetite. The first one appears at 360 to 375° C, the second one at 580° C. The value of the first peak is slightly modified by varying grain-size. The authors have come to the conclusion that magnetite, heated in air, undergoes two stages of oxidation. The first one, is a surface oxidation into haematite, the other one being a complete oxidation into haematite. They have also pointed out that in the course of the heat treatment, no trace of γ-Fe_2O_3-formation was observable. According to LEPP [5] superficial oxidation — considered as first stage — seems to be in connection with specific surface. Examining synthetic magnetites, GEITH [2] has interpreted the result of d. t. a. investigations as follows: the first exothermal peak should represent the initial oxidation into γ-Fe_2O_3, and this is followed by the complete alteration from modification γ into modification α. According to LEPP, too, the first exothermal peak should represent the oxidation into Fe_2O_3.

In order to investigate the nature of the first exothermal peak, LEPP pulverized natural magnetite to the grain-size of 0,061 mm (—250 mesh), and heated it to 430, then to 500° C. Both temperatures are above that of the first exothermal peak and below that of the second one. The X-ray diagram of this product has given a very strong magnetite pattern. Very few of the even strongest haematite-lines were to be seen. This phenomenon probably indicates that only a very small amount of magnetite has oxidized. The examination of the ferrous iron-content, however, indicates a quite different situation. While the composition of the original substance approximated to the theoretical composition of magnetite, after having been heated to 430° C the Fe_2O_3/Fe_3O_4 ratio was 34 : 66 in it, in the substance heated up to 500° C the ratio was 45 : 55. This would indicate, on the other hand, that the few and weak haematite lines of the X-ray diagrams of the samples that underwent heat treatment, would not represent complete oxidation, and the oxidation taking place below 500° would represent a change into γ-Fe_2O_3. The broadening of the above mentioned lines on the X-ray diagrams seems to be due to the fact that the dimensions of the unit-cell of γ-Fe_2O_3 differ but slightly from those of magnetite.

As a result of his d. t. a. investigations, LEPP infers the following phases in the course of the rapid oxidation of magnetite:

$$4\ Fe_3O_4 + O_2 \longrightarrow 6\ \gamma\text{-}Fe_2O_3$$

The reaction starts at about 200° C and its maximum is at 350 or 400° C.

$$\gamma\text{-}Fe_2O_3 \longrightarrow \alpha\text{-}Fe_2O_3$$

The reaction starts at about 375° C and ends at 525 to 550° C.

$$4\ Fe_3O_4 + O_2 \longrightarrow 6\ \alpha\text{-}Fe_2O_3;$$

the reaction starts at 550 to 570° C.

After all, the rate of magnetite oxidation, at given pressure and temperature may be considered as a function of the specific surface of the matter and of the order in the crystal lattice.

DESCRIPTION OF THE OCCURRENCES

In the western and central parts of the Mátra, oxyandesitic petrofacies is frequently observable along andesite dikes. Though these occurrences are not very thick, they represent, however, a characteristic part of the massive andesite [4, 7].

Between Tar and Hasznos on one hand, as well as Kékes and Határpatak-tető on the other hand, andesitic lava flowed sometimes on andesite tuff or on lava-bond agglomerate. In these places, the surface of the lava-bond agglomerate and andesite-tuff was somewhat more mature, its water-content was higher than that of the lava. In ordinary facies, the colour of the lava is either medium grey or yellowish grey (pumiceous). If the lava flows on such a surface, a volatile mass of higher pressure appears below the lava, because of the higher water-content of the floor. It is one of the effects of the above-mentioned phenomenon that the lower part of the lava-flow becomes scoriaceous. *Scil.* after the escape of volatiles, the lava becomes viscous to such a degree, that the porosity produced by volatiles remains.

In the valley of the Csevice-brook, near the Tar we could observe an occurrence of this kind. There, the grey, yellovish grey andesite-tuff crops out with a 45—225° strike and 23° SE dip, near point 279. The succession of strata is as follows: Down below, one finds grey, fine-grained, andesite tuff of sandy appearance. This is overlain by a 60 cm thick stratum of yellowish grey andesite tuff with lapillis, which occurs very frequently in this territory, then about 40 cm thick, red oxyandesite tuff. The latter is in contact with the andesitic lava, the lower 20 to 40 cm thick part of which consists of red oxyandesite, overlain by the normal, medium grey, more compact andesite.

The chemical composition of the normal, yellowish grey andesite tuff (1) and that of the average oxyandesite tuff (2) are as follows (analyst: M. EMSZT):

	1.	2.
SiO_2	51,47%	50,87%
TiO_2	0,47	0,51
Al_2O_3	18,88	20,83
Fe_2O_3	6,04	7,63
FeO	1,77	—
MnO	0,12	0,12
MgO	1,90	1,67
CaO	6,32	7,38
Na_2O	1,20	1,96
K_2O	0,76	1,04
H_2O^+	5,66	5,42
H_2O^-	5,22	2,63
P_2O_5	0,05	0,16
	99,86%	100,22%

If one compares the data of the two analyses, one finds no considerable difference but in the change in Fe_2O_3—FeO-content and in $-H_2O$-content.

The yellowish grey andesite tuff has been formed in an oxidizing environment where FeO-content had been lower. In the oxyandesite tuff, however, the whole FeO oxidized into Fe_2O_3, in conformity with the new conditions of equilibrium produced by the heat effect of the lava, consequently a considerable change took place in the ferrous/ferric ratio. The decrease in $-H_2O$-content is evident, too, since — on the effect of heat — a part of the water, namely adsorbed, unstably combined water, easily passes into the vapour phase producing the scorification of the overlying lava. The andesite-tuff zone turning into oxyandesite tuff is thin in this case, because the overlying lava flow was very thin, too.

The thin lava flow, lying over the andesite tuff, has been broken up by erosion *(Fig. 1)*. The porosity of the rock has secondarily developed over the scoriaceous oxyandesite. Cavities are filled up with chlorite, chalcedony, and yellowish, rhombohedral calcite.

Fig. 1. Andesite-lava broken up by erosion; in the lower part oxyandesite. Tar, Csevice-valley.

The chemical composition of both rock types is following (Grey, porous andesite (1), oxyandesite (2), analyst: L. JANKOVICH):

	1.	2.
SiO_2	50,91%	50,79%
TiO_2	0,76	0,88
Al_2O_3	24,38	19,27
Fe_2O_3	3,81	9,59
FeO	2,59	1,70
MnO	0,34	0,25
MgO	0,33	0,69
CaO	10,40	9,33
Na_2O	2,67	2,75
K_2O	1,29	1,24
H_2O^+	1,37	2,01
H_2O^-	1,34	1,14
P_2O_5	0,13	0,19
CO_2	0,17	0,32
	100,39%	100,15%

If one compares the chemical analyses of both rocks, considerable differences are to be found, as a matter of fact, only in the Fe_2O_3—FeO-values. While the value of O_{Fe} is approximately 3 in the case of the lava flow — indicating the subaerial congealation of the latter — that of the oxyandesite is 11,3. This difference becomes visible in the colour of the rocks.

A similar phenomenon was observable in the Central Mátra, too. Along the northern ski-track of the Kékes, red oxyandesite appears in a clastic form at the higher levels and in massive occurrences at the lower levels. The latter can be considered as a thinner, intercalated lava flow under the younger andesite of the Kékes. As this formation is covered in a large measure, it is very difficult to determine more exactly its position. The rock *in situ* rises to 5 or 6 m over the surroundings, at the western side of the ski-track.

Under the microscope, particularly in case of considerable magnification, the rock is red-translucent. The groundmass is completely covered with haematite grains of the order of magnitude of some microns, consequently the microlithe of the rock-forming minerals are not discernible. Porphyritic felspars are well distinguishable and contain, among others, haematite inclusions, too. Around the inclusions, one can sometimes observe ochreous colouration which is already an effect of colouring by limonite. The clay-mineralization of the felspars is not considerable. Pyroxenes are often surrounded by an opacitic border, which indicates a higher degree of oxidation, too. Ore inclusions frequently occur in the latter.

To the North of the Határpatak-tető, one finds likewise oxyandesite on the surface, overlain by grey andesite *in situ*. The situation is the same as in the Csevice valley, *i. e.* the andesite tuff is overlain by a thin lava flow, the very thin lower part of which altered into oxyandesite.

On the western side of the Közbérc, at 500 to 550 m above sea-level, on an almost N—S ridge consisting of grey andesite, the upper part of the andesite tuff — under the massive rock — changed into oxyandesite tuff, the clastics of which can be followed at great length, on the western slope of the mountain. Thus one finds once more the interrelation between andesite tuff and lava.

At the middle course of the Csonka brook one also finds oxyandesite on the agglomeratic andesite tuff. It is well observable, on this occurrence, that coloured minerals are surrounded with ore border, *i. e.* there appears opacitization.

On the southern slope of the mount Várhegy at Hasznos, there is an intercalation of banked, lamellar andesite, in the lava-bond agglomerate. The lower part of the andesite is not opened up, thus we do not know the conditions in this part, while the banked, grey, augitic hypersthene-andesite gradually passes into oxyandesite *(Fig. 2)*. This zone can be followed along the exposure. From the appearance of the oxyandesite one can infer that the alteration into oxyandesite of the upper part of the already congealed rock was facilitated By the still hot, lava-bond agglomerate which flowed on the andesite. The narrow zone is a necessary consequence of the relatively small amount of lava-

Fig. 2. Banked andesite-lava overlying by oxyandesitic and hydroandesitic varieties. Hasznos, Várhegy.

bond agglomerate, its effect is observable only on a narrow stripe. The increase in haematite-content of the rock is limited to the same stripe, too. Volatiles probably did not play any important part, here, in the basement of the massive rock. This is probably why scorification, appearing elsewhere, is not observable, here. The results of the chemical analyses of fresh, grey andesite (1) and red oxyandesite (2) are following (analyst: M. BARANYI):

	1.	2.
SiO_2	55,40%	54,56%
TiO_2	1,16	1,01
Al_2O_3	17,69	16,91
Fe_2O_3	5,20	8,53
FeO	3,30	2,60
MnO	0,10	0,18
MgO	2,76	2,65
CaO	7,45	6,92
Na_2O	2,82	2,63
K_2O	1,65	1,44
H_2O^+	0,85	1,59
H_2O^-	0,79	0,49
CO_2	0,54	0,74
P_2O_5	0,09	0,12
	99,90%	100,37%

Thus, while the first analysis shows the composition of the characteristic andesitic lava of the environs, where the degree of oxidation is low [3, 15], too, there is no considerable difference, in the case of oxyandesite, but in the ferrous/ferric ratio, in consequence of which there is an increase in the degree of oxidation (6,56).

The oxyandesite tuff appearing on the ridge running to the NE of the watch-house of Zsillő, at Hasznos, is also interesting. There, the red andesite tuff with lapillis or sandstone inclusions is to be found in the upper part of the Helvetian andesite tuff appearing on the schlieric formation. Since sandstone inclusions in the tuff show a weak contact effect [3], one can infer that there was a jet of high-temperature pyroclastics which, having a loose structure on the surface, altered into oxy-tuff in the oxidizing environment. To the East, there is andesitic lava on the surface, but for the moment it is difficult to say wether it had any affect on the formation of the oxyandesite tuff.

In this point of view, it was interesting to observe the contact zone of the dikes. When the andesite dike passed in schlier sandstone, a very weak contact effect appeared on the sandstone and a very slight discolouration on the andesite. The same was observed by BOGNÁR and PÓKA [1], as for the andesite dikes at Nagybátony. In the latter dikes, calcite appears very frequently, which is probably in connection with the marly facies of the schlieric formation. The pyroxene-content of this andesites often shows a slight chloritization.

The other dikes run in andesite tuff. The phenomena observable here are much the same as in lava flow on andesite tuff. Since, in the case of dikes, there is a still smaller amount of lava, the effect will be relatively less intense.

This phenomenon can be followed along the valley „Szakadás-gödre", one of the northern branches of the Csevice valley. Here, in the upper part of the valley, a roughly 6 m large, almost perpendicular dike, with 170—350° strike, appears in the agglomeratic andesite tuff. On the contact of the two rocks, both in andesite and andesite tuff, the development of the oxy-character is observable. On a narrow stripe, tuff and dike take a red colour, the dike becoming porous, with slight chloritization.

Results of analyses of both types (1. fresh, grey andesite, 2. red, scoriaceous andesite; analyst: L. JANKOVICH) are following:

	1.	2.
SiO_2	48,40%	50,25%
TiO_2	0,66	0,88
Al_2O_3	27,45	23,90
Fe_2O_3	3,62	5,28
FeO	2,26	1,83
MnO	0,15	0,13
MgO	1,10	0,69
CaO	9,98	9,46
Na_2O	2,73	2,90
K_2O	1,46	1,37
H_2O^+	1,02	1,51
H_2O^-	0,92	1,69
CO_2	0,60	0,25
P_2O_5	0,16	0,16
	100,53%	100,30%

Thus, the difference is not considerable, there either, in the degree of oxidation (3,2 and 5,8). In the red oxyandesite O_{Fe} is over 5, but this value is not an extraordinary one. No opacitization takes place here, as the rock is practically free from coloured minerals. The increase in Fe_2O_3-content represents, here too, haematite.

Taking into consideration the trend of the Fe_2O_3 ratio, one can point out that only the increase in numerical values is regular in connection with the changes in degree of oxidation, but it was impossible to determine any limit value allowing the delimitation between oxyandesites and other types. There are considerable differences in the Fe_2O_3/FeO ratio between the normal and oxy-varieties of each type:

The determined weight-percent quantities of Fe_2O_3 and FeO are recalculated to 100 percent.

Rock	Fe_2O_3/FeO	
	in fresh rock	in oxy-variety
andesite tuff	77:23	100:0
lava flow	60:40	85:15
lava agglomerate	61:39	93:7
andesite dike in andesite tuff	62:38	74:26

Comparing the data of analysis of oxyandesites to those of the fresh rock, one could generally point out that the extreme values of SiO_2, Al_2O_3 decreased in the oxy-rocks; there is a trend towards equalization in some measure, in oxy-rocks, except for the value of Fe_2O_3. Besides, CaO- and MgO-content also decreased in oxyandesites. The behaviour of the alkalis has not proved regular.

Tu sum up, it was proved that, on the contact of andesite lava or andesite dike with andesite tuff, oxyandesite with considerable haematite-content has been formed, the amount of wich depended on the mass of the lava. The

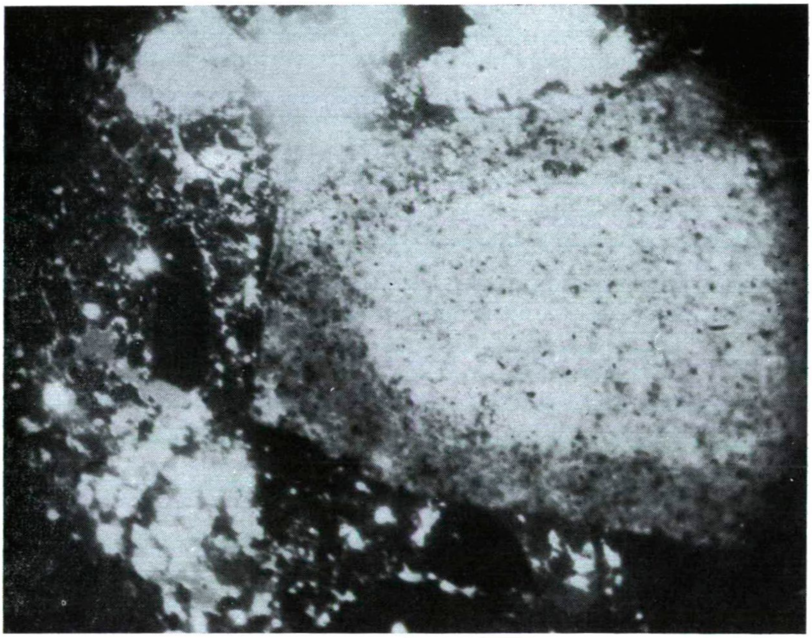

Fig. 3. Microphotograph of a sandstone inclusion with contact border in oxyandesite-tuff. East from the watch-house of Zsilo, Hasznos. Crossed nicols, magnif. 40×.

seemingly capricious appearance of red oxyandesite or oxy-tuff actually shows some regularities, and it is due to the different degrees of denudation that we often find, on the surface, normal grey andesite tuff and oxy-tuff, or various varieties of andesite, side by side. In these oxyandesites, there is always a considerable amount of haematite which plays an important part in the red colouration of the rock, too.

When the lava flows on the surface of the tuff, or it forms a dike in the andesite tuff, the temperature of the latter is still over the formation temperature of α-Fe_2O_3, consequently magnetite already present in the lava directly altered into α-Fe_2O_3, and produced the red colour of the rock. The same holds for the magnetite-content of the tuff. The volatile-content of the tuff, on the other hand, primarily facilitates scorification, while secondarily enables the formation of volatile minerals produced by the decomposition of the mineral (chlorite, clay minerals, etc.)

In andesite tuff, the iron-content often appears in the form of $Fe(OH)_3$, in that of goethite or, in case of lower p_H, as lepidocrocite. At higher temperature, this will alter into α-Fe_2O_3, too. Consequently the red colouration of oxyandesite tuff is due, first of all, to α-Fe_2O_3.

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ON THE RELATIONSHIP BETWEEN THE LITHOLOGY OF THE ABRASION AREA AND THE TRANSPORTED SEDIMENTS

By B. MOLNÁR

Geological Institute of the József Attila University, Szeged

The method based on the examination of heavy-mineral composition is taking a more and more important part in the study of the geology and hydrogeology of clastic sediments in Hungary, too; the data obtained in this way may considerably contribute to reach right conclusions on the hydrogeology and palaeohydrography of the respective area.

The catchement area of each river has its characteristic lithology, thus the lithological and mineralogical composition of the alluvia coming from this area in the course of the erosion will probably be characteristic of the catchment area. If heavy-mineral compositions of the alluvia of different rivers — as a factor characteristic of the genesis of the sediment — is known, we shall be able to distinguish their recent deposits from the older ones, to recognize their horizontal and vertical extension, to point out more precisely the former courses of the rivers: these examinations thus contribute to get a complete palaeohydrographical picture.

In Hungary, examinations of this kind may be of particular importance, scil., in the basins, the thickness of clastic, young, Tertiary and Quaternary strata is very considerable, and they consist of fluvial deposits, for the most part. Later on, one will be able to determine their origin, if, at first, the composition of the alluvia of recent rivers will be known, in order to draw conclusions concerning the origin of older deposits.

The above-mentioned possibility as well as the demands of Hungarian researchers working in this field have pressed for a detailed examination of this problem of the day, thus we have carried out heavy-mineral examinations on every important river of Hungary. We have examined how far the geology of the catchment area was reflected by the heavy-mineral composition, and, here and there, we have examined fossil fluvial sediments, too, in order to determine the genesis of the latter. Grain size distribution of each sample was determined, and the results plotted on grain-size-distribution graphs. (See grain-size-distribution graphs.) It was necessary because grain size distribution affects heavy-mineral composition, too. [14]

After the usual bromoform separation, heavy-mineral composition of the fraction 0,1 to 0,125 mm in diameter, or — if the sample contained but a little of this fraction, *i. e.* in the case of coarser and better sorted matters — that of the 0,1—0,2 mm fraction was determined. A table of the detailed results, grouped according to the genesis of the minerals, in the case of metamorphic minerals according to the succession of the zones of origin (crystalline schist zones) has been drawn up. (See Table).

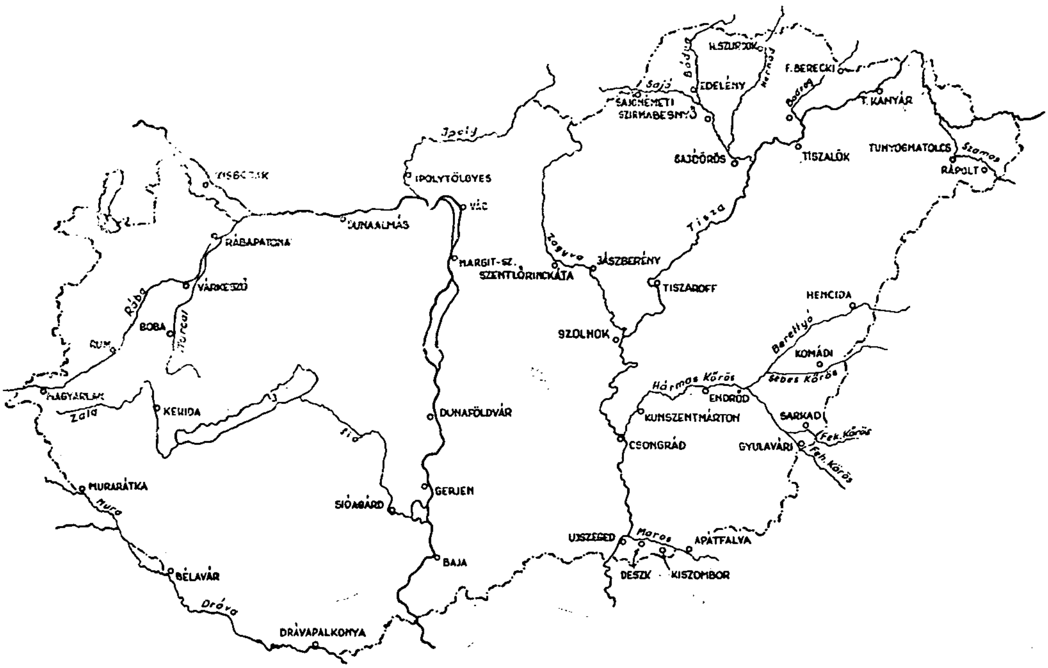


Fig. 1. Places of occurrence of the samples examined.

On the left-side of the Table we have indicated the rivers or the places of occurrence of the samples examined, respectively, while on the right-side the total quantity of the heavy-minerals to be found in the fraction examined, in proportion to that of the light minerals, as well as the fraction examined and the dominant grain diameter read of the grain-size-distribution graphs, in millimetres, are to be seen.

We have also graphically plotted the percentages of the dominant minerals characteristic of each river and catchment area, thus differences and changes taking place, in the case of rivers of some length, during their course are easily observable.

THE DANUBE REGION
(The Danube and its tributaries)

Among the *Danubian* alluvia, the first two samples were taken at Kisbodak, near the Austro—Czechoslovak border, and at the more distant Dunaalmás, respectively. The samples consist, for the most part, of fine-grained (0,1 to 0,2 mm) and, to a lesser degree, of medium-grained sand (*Fig. 2*, A). (As for

Serial number	PROVENANCE	Dominantly magmatic minerals: Hypersthene	Other rhombic pyroxenes	Monoclinic pyroxenes*	Darkbrown amphibole	Light brown amphibole	Magnetite	Olivine	Biotite	Apatite	Zircon	Volcanic glass	Dominantly metamorphic minerals: Chlorite	Tourmaline	Epidote	Zoisite	Rutile	Bluish green amphibole. (Hornblende)	Actinolite-tremolite	Anthophyllite	Topaz	Garnet	Staurolite	Cyanite	Andalusite	Glaucophane	Other minerals: Calcite-dolomite	Anhydrite	Limonite	Other micas	Weathered minerals	Total quantity of the heavy-minerals	Diameter of the fraction examined, in mm	Dominant grain diameter
1.	Duna (Kisbodak)	—	3,1	7,4	1,0	3,5	1,5	—	—	1,5	—	—	11,1	0,5	1,1	1,0	—	3,0	0,5	—	1,0	20,1	1,5	0,5	—	—	20,1	—	1,0	—	20,6	10,4	0,1—0,125	0,18
2.	Duna (Dunaalmás)	0,5	3,5	8,2	3,5	—	11,8	—	0,5	1,1	0,5	—	5,4	0,5	1,1	—	1,1	4,1	2,3	0,5	0,5	25,1	1,1	—	—	—	7,6	—	1,1	—	20,0	21,3	0,1—0,125	0,13
3.	Duna (Váctól É-ra)	8,8	1,1	5,6	7,8	0,5	6,1	—	—	1,1	—	—	3,9	1,6	1,1	—	—	3,9	0,5	1,1	—	31,5	1,6	1,6	—	—	2,3	—	—	0,5	19,4	17,3	0,1—0,125	0,34
4.	Duna (Margitsziget)	1,1	2,1	5,9	8,4	4,3	14,9	—	—	1,1	0,5	—	2,1	1,1	1,6	—	0,5	1,6	1,6	—	—	34,0	1,6	1,1	—	—	2,6	—	1,1	—	12,8	29,1	0,1—0,125	0,32
5.	Duna (Dunaföldvár)	0,5	1,1	5,9	10,7	4,8	4,8	—	—	0,5	—	—	7,5	0,5	1,1	—	—	5,3	1,6	—	—	26,2	1,1	1,1	—	—	4,3	—	1,6	—	21,4	10,9	0,1—0,125	0,17
6.	Duna (Gerjen)	—	4,3	9,0	2,1	6,4	6,4	—	—	1,1	0,5	—	9,0	2,1	1,6	0,5	—	6,4	1,6	0,5	—	16,0	1,6	1,6	—	—	3,2	—	1,6	—	24,5	11,5	0,1—0,125	0,21
7.	Duna (Baja)	0,5	3,7	5,3	1,1	4,2	2,7	—	—	1,6	—	—	16,5	0,5	1,6	0,5	—	11,2	2,7	0,5	—	16,0	1,1	2,1	—	—	3,7	—	1,6	—	22,9	3,9	0,1—0,125	0,18
8.	Rába (Magyarlak)	0,6	1,7	10,4	0,6	3,3	5,5	—	—	—	—	—	9,9	2,2	—	—	0,6	3,3	2,8	—	—	32,6	—	2,2	—	—	—	—	1,7	—	22,6	4,3	0,1—0,2	0,57
9.	Rába (Rum)	1,9	6,7	8,6	1,8	4,2	10,4	—	—	0,6	—	—	6,1	3,1	0,6	1,2	0,6	1,8	2,4	—	—	39,0	—	0,6	—	—	—	—	0,6	—	9,8	14,0	0,1—0,125	0,25
10.	Rába (Várkesző)	0,5	3,6	7,1	—	3,6	6,5	—	—	—	—	—	18,9	1,2	—	0,5	—	0,5	2,3	—	—	3[,3	0,5	0,5	—	—	—	—	1,7	—	21,3	11,2	0,1—0,2	0,23
11.	Rába (Rábapatona)	—	2,8	6,1	0,5	3,8	8,2	—	—	2,2	—	—	8,8	1,1	0,6	0,6	1,7	2,8	1,7	—	—	39,6	1,1	0,6	—	—	—	—	1,7	—	17,1	6,7	0,1—0,2	1,30
12.	Marcal (Boba)	—	3,9	4,9	—	1,1	2,3	2,8	—	1,6	—	—	5,6	2,8	1,6	—	0,5	2,8	2,8	—	—	32,0	1,6	1,6	—	—	0,5	—	2,3	2,8	26,5	10,5	0,1—0,2	0,25
13.	Zala (Kehida)	—	2,6	7,4	2,0	2,7	9,4	—	—	3,4	—	—	15,4	2,0	2,0	2,7	0,7	1,3	2,7	0,7	—	21,4	0,7	0,7	—	—	8,7	—	1,3	—	12,2	6,5	0,1—0,125	0,20
14.	Sió (Sióagárd)	—	5,2	7,2	1,0	—	4,6	0,5	—	3,1	—	—	9,3	2,1	4,2	4,2	—	—	2,1	0,5	—	16,1	1,5	3,1	0,5	—	3,7	—	0,5	—	30,6	4,7	0,1—0,125	0,16
15.	Mura (Murarátka)	—	0,7	2,6	0,7	2,6	2,0	—	—	0,7	—	—	3,3	0,7	0,6	2,0	—	6,0	2,0	—	—	60,0	0,7	—	0,7	—	—	—	0,7	—	14,0	46,0	0,1—0,2	0,27
16.	Dráva (Bélavár)	—	3,6	6,6	1,0	2,6	6,6	—	—	2,1	—	—	5,1	ε,7	2,1	1,5	0,5	7,6	1,5	—	—	35,8	0,5	1,0	—	—	1,5	—	0,5	—	16,2	25,9	0,1—0,125	0,18
17.	Dráva (Drávapalkonya)	—	3,7	1,1	0,5	3,2	3,2	—	—	0,5	—	—	19,1	0,5	—	1,6	1,1	3,7	2,6	—	—	19,0	0,5	0,5	—	—	13,8	—	3,2	—	22,2	26,2	0,1—0,125	0,32
18.	Ipoly (Ipolytölgyes)	41,9	—	11,3	7,8	—	20,6	—	2,1	1,4	—	—	—	—	—	0,7	—	—	—	—	—	6,4	—	—	—	—	—	—	—	—	7,8	11,6	0,1—0,2	0,48
19.	Tisza (Tiszakanyar)	22,6	1,1	12,4	6,5	1,0	9,7	—	—	1,1	—	—	9,7	0,5	0,5	—	—	0,5	—	—	—	10,2	1,1	—	—	—	0,5	—	1,1	3,2	18,3	7,7	0,1—0,2	0,28
20.	Tisza (Tiszalök)	44,4	3,5	13,1	4,2	1,4	9,7	—	—	—	—	—	1,4	1,4	—	—	—	1,4	—	—	—	5,6	1,4	—	—	—	—	—	1,4	—	13,1	15,7	0,1—0,2	0,23
21.	Tisza (Tiszaroff	13,3	1,3	11,3	4,7	2,0	7,3	—	—	0,7	—	—	13,3	0,7	2,7	—	—	0,7	0,7	—	—	8,0	—	—	—	—	—	—	5,3	0,7	27,3	1,2	0,1—0,125	0,10
22.	Tisza (Szolnoktól É-ra)	7,1	2,6	6,2	7,1	1,8	5,3	—	1,3	0,9	—	—	19,0	1,8	0,9	0,4	—	3.6	1,8	—	—	4,9	—	0,4	—	—	2,2	—	3,1	11,9	17,7	1,6	0,1—0,125	0,13
23.	Tisza (Csongrád)	15,0	1,7	8,1	2,9	—	1,7	—	0,6	—	—	—	1,7	0,6	1,2	0,6	—	0,6	0,6	0,6	—	45,0	1,2	—	—	—	0,6	—	1,7	—	15,6	18,0	0,1—0,2	0,18
24.	Tisza (Újszeged)	8,1	5,5	13,1	6,5	2,0	9,5	—	—	2,0	0,5	—	4,0	0,5	2,0	0,5	1,0	8,1	2,5	—	—	17,1	1,0	1,5	—	—	0,5	—	3,0	—	11,1	5,2	0,1—0,125	0,15
25.	Zagyva (Szentlőrinckáta)	6,2	2,1	4,6	4,1	—	8,7	—	1,0	0,5	—	—	0,5	2,1	1,0	—	—	1,5	0,5	0,5	—	42,6	—	—	—	—	1,0	—	2,1	1,0	20,0	5,4	0,1—0,2	0,60
26.	Zagyva (Jászberény)	7,7	0,6	3,8	7,1	—	6,5	—	1,9	1,3	—	—	0,6	1.3	3,3	—	0,6	3,3	—	—	—	37,5	0,6	1,9	—	—	1,3	—	3,3	—	17,4	2,4	0,1—0,2	0,19
27.	Sajó (Sajónémeti)	1,1	4,6	6,8	1,1	5,2	13,9	—	—	2,9	—	—	5,8	1,7	0,5	—	1,1	4,6	1,1	0,5	—	10,4	0,5	0,5	—	—	1,1	—	1,7	2,3	32,6	5,0	0,1—0,125	0,19
28.	Sajó (Szirmabesnyő)	9,4	1,1	2,8	2,3	1,8	12,9	—	—	1,8	—	—	6,3	1,1	—	—	—	1,1	1,8	—	—	32,8	1,1	—	—	—	0,5	—	6,3	0,5	16,4	5,7	0,1—0,2	1,10
28.	Sajó (Sajóőrös)	18,9	1,7	5,7	1,1	0,6	19,4	—	—	—	—	—	9,7	0,6	—	—	0,6	0.6	0,6	—	—	9,7	0,6	—	—	0,6	1,7	0,6	4,5	—	22,8	4,4	0,1—0,2	0,60
30.	Bódva (Edelény)	2,6	—	3,9	0,7	—	12,5	—	—	—	—	—	3,9	1,9	—	—	—	—	0,7	—	—	1,3	0,7	—	—	4,6	—	5,3	29,6	—	32,3	2,1	0,1—0,2	0,47
31.	Hernád (Hernádszurdok)	29,3	2,1	5,7	—	—	15,8	—	—	—	—	—	7,1	0,7	—	—	—	—	—	—	—	6,5	—	—	—	—	3,5	—	2,1	—	27,2	8,7	0,1—0,2	0,45
32.	Bodrog (Felsőberecki)	6,9	0,5	16,2	5,8	1,7	15,0	—	—	0,5	—	0,5	10,4	1,7	1,7	—	0,5	1,7	1,7	—	—	9,9	0,5	0,5	—	—	0,5	—	4,1	—	19,7	1,2	0-1—0,125	0,12
33,	Bodrog (Bodrogkeresztúr)	22,8	3,4	11,0	4,1	—	4,8	—	—	2,2	0,7	—	13,1	0,7	0,7	—	0,7	3,4	—	—	—	12,4	—	—	0,7	—	0,7	—	4,1	—	14,5	1,0	0,1—0,125	0,11
34.	Szamos (Rápolt)	20,0	0,6	14,2	5,9	1,3	6,5	—	—	0,6	—	—	7,1	1,2	1,3	—	—	3,9	0,6	—	—	16,1	1,3	1,3	—	—	1,3	—	2,7	0,6	13,5	13,0	0,1—0,2	0,53
35.	Szamos (Tunyogmatolcs)	10,6	3,8	6,2	3,8	0,6	13,7	—	—	1,3	0,6	—	1,3	0,6	1,3	—	—	1,3	0,6	—	—	13,7	0,6	1,9	—	—	3,1	—	5,0	—	30,0	16,4	0,1—0,125	0,32
36.	Berettyó (Hencida)	10,2	1,8	10,0	18,6	0,6	10,2	—	0,6	1,2	—	—	3,6	2,2	—	—	—	1,8	1,2	—	—	13,0	1,2	2,2	—	—	—	—	4,8	—	16,8	3,4	0,1—0,2	0,36
37.	Sebes Körös (Komádi)	—	2,2	3,8	10,7	1,1	15,3	—	—	1,7	0,5	—	2,2	2,7	2,2	—	1,1	0,5	—	—	—	35,6	0,5	0,5	—	—	—	—	2,2	—	17,5	14,8	0,1—0,125	0,20
38.	Fekete Körös (Sarkad)	10,7	2,4	11,8	8,9	3,6	8,3	—	—	1,1	—	—	4,2	0,6	2,4	1,1	—	1,8	0,6	—	—	10,1	—	0,6	—	—	—	—	2,9	—	28,9	3,0	0.1—0,125	0,16
39.	Fehér Körös (Gyulavári)	13.6	1,8	24,6	14,8	—	11,7	—	—	—	—	—	3,7	0,6	—	—	—	—	0,6	—	—	1,8	—	—	—	—	—	—	3,7	—	19,1	14,0	0,1—0,2	0,49
40.	Hármas Körös (Endrőd)	5,3	4,3	13,4	16,7	2,7	4,3	—	0,5	0,5	—	—	5,9	2,1	2,1	0,5	0,5	2,7	1,6	—	—	13,4	2,1	0,5	—	—	—	—	4,8	1,6	14,5	5,3	0,1—0,125	0,10
41.	Hármas Körös (Kunszentm.)	9,2	3,8	15,5	17,9	7,6	5,4	—	—	1,1	—	—	1,1	0,6	2,2	1,1	0,6	1,1	1,6	0,6	—	4,9	0,6	0,6	—	—	1,6	—	2,2	—	20,7	5,5	0,1—0,125	0,15
42.	Maros (Apátfalva)	10,0	1,6	13,9	8,3	1,1	11,1	0,6	—	0,6	—	—	3,3	0,6	1,1	—	0,6	1,1	1,6	—	—	23,3	2,8	0,6	—	—	1,1	—	0,6	—	16,1	13,6	0,1—0,2	0,55
43.	Maros (Kiszombor)	11,0	1,9	10,2	11,0	5,1	7,0	—	0,6	3,3	—	—	4,5	0,6	1,9	1,9	0,6	4,5	5,1	—	—	8,4	0,6	0,6	0,6	—	2,5	—	1,9	—	16,1	5,9	0,1—0,125	0,24
44.	Maros (Deszk)	4,9	2,9	12,8	10,3	2,5	9,0	—	—	0,9	—	—	8,4	0,9	2,5	—	0,5	4,9	2,5	—	—	5,4	0,9	0,9	—	—	1,9	—	1,9	—	25,1	7,8	0,1—0,125	0,16

* In alluvia of the Danube region dominantly diopside, in alluria of the Tisza region dominantly augite.

the nomenclature of sandy sediments, we apply the size grade elaborated by I. MIHÁLTZ and GY. BÁRDOSSY) [1, 8, 9]. Heavy-mineral compositions have been determined on the basis some 200 grains in the case of major rivers, while on that of about 100 or 150 grains in the case of minor rivers, the examination

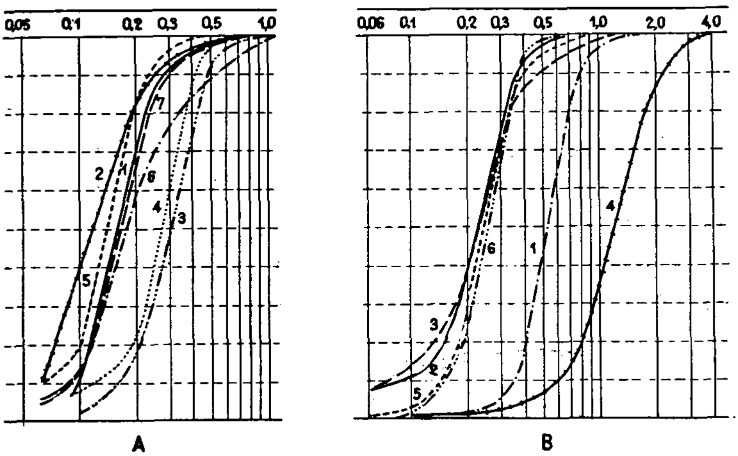


Fig. 2. a
Duna
1. Kisbodak
2. Dunaalmás
3. Vác N.
4. Margit-Isle
5. Dunaföldvár
6. Gerjen
7. Baja

b
Rába
1. Magyarlak
2. Rum
3. Várkesző
4. Rábapatona

Marcal
5. Boba

Mura
6. Muraratka

of such a quantitity of grains already gives a true picture of the composition. [10] The important part played by metamorphic minerals is very characteristic, and it proves that these minerals come from the Alps, *i. e.* from an area consisting of metamorphic rocks.

The quantity of calcite and dolomite is greater, here, as compared to other Danubian samples, at Kisbodak it amounts to 20%, at Dunaalmás to 7,6%, too. This relatively high degree indicates the effect of the NE Limestone Alps, while to the east of this territory, the quantity of the above-mentioned minerals becomes smaller, because of the well-known solubility of carbonate minerals as well as because the Rába river itself does not transport carbonate minerals, therefore the alluvia of the Rába and probably those of its tributaries coming from the north are weakening this character.

Fig. 3. shows the heavy minerals of the Danube sand at Dunaalmás. On the left-hand side, in the middle, it is observable that even the hard cyanite is rounded, which indicates transport from a considerable distance: from the Alps. The light-coloured minerals with uneven fractures are garnets, the almost globular opaque minerals are magnetites. The other dark minerals are weathered or incrustated ones.

The effect of hypersthene-amphibole-andesite and garnet-bearing andesite, andesitic tuff — Börzsöny and Dunazug Mountains — are demonstrable in the Danubian alluvia, too. Later on, we shall see that the tributaries, brooks of this region transport great quantities of alluvia rich in magmatic minerals. Among

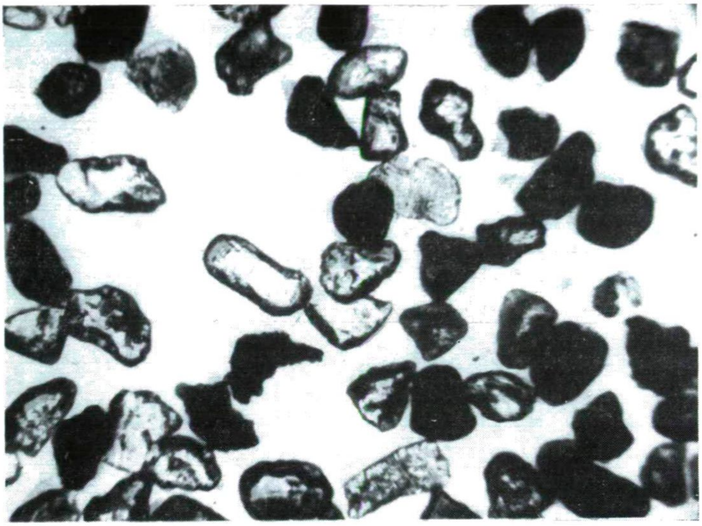


Fig. 3. Heavy minerals of the Danube sand at Dunaalmás, from the 0,1 to 0,125 mm fraction. (Photographs taken by polarizing microscope, nicols, minerals embedded in nitrobenzene).

the above-mentioned Danubian samples, it was only that of Dunaalmás which contained 0,5% of hypersthene, while to the north of Vác the amount of this characteristically magmatic mineral is as high as 9%.

In the rivers of Hungary, there are two types of brown amphibole: the one is a dark variety, rich in iron, the other is more light-coloured and less rich in iron. The ratio expressed in percentage of the two varieties is often characteristic, therefore we have everywhere distinguished the two types.

In *Fig. 4.* (Diagram I), it is shown that from Vác, *i. e.* from the volcanic mountains the quantity of dark-brown amphibole is gradually increasing to Dunaföldvár where it is above 10%. On the other hand, the maximum of light-brown amphiboles, 6,4%, is to be found at Gerjen.

The shift of the maxima of these three minerals coming from volcanic areas, as compared to each other, shows the resistance to weathering of the minerals, too. Hypersthene is the most friable one among them, this is why it occures very scarcely in the drift sands of the region situated between the Danube and the Tisza [11—12].

In *Fig. 5,* in the 0,1 to 0,125 mm fraction of the Danubian sand sampled at Dunaföldvár are discernible, beside the garnet, the dark-brown (dark-shaded columnar minerals) and light-brown (light-shaded columnar minerals) amphiboles. In the sample of Dunaalmás such minerals were not yet observed.

I.

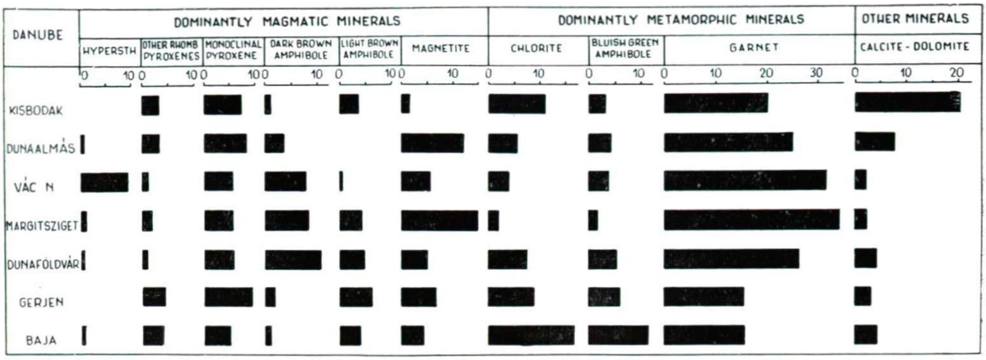


Fig. 4. (Diagram I.) Dominant heavy-mineral sorts in the alluvia of the Danube.

Because of its great specific weight, magnetite reacts the most rapidly to the changes in conditions of deposition, therefore — in the same way as in earlier investigations — we could not point out any regularity concerning the changes in the amount of this mineral.

The amount of garnet is fairly considerable in every sample taken from the Danube, it is varying between 16 and 34%, reaching its maximum in the samples coming from Vác and the Margaret Island. It has been pointed out, by previous examinations, that finer fractions extracted from coarser-grained sand always contained considerable quantities of garnet, and the total amount

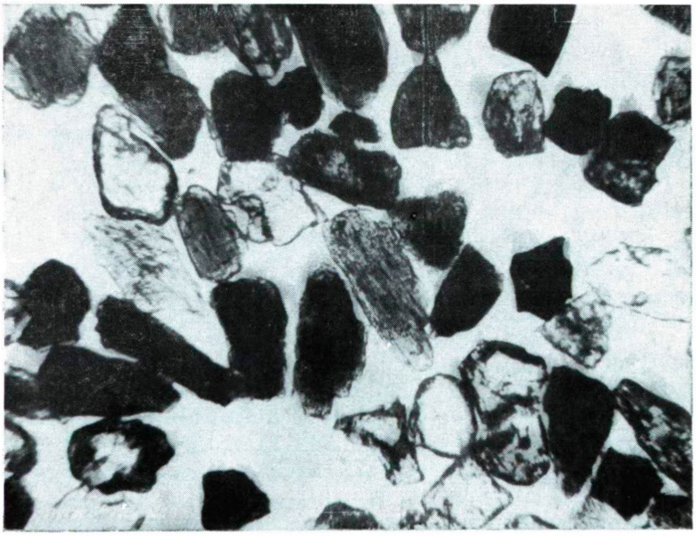


Fig. 5. Heavy minerals of the Danube sand at Dunaföldvár, from the 0,1 to 0,125 mm fraction.

of heavy-minerals in these fractions was always greater, too. [14]. The grain size distributions of samples of Vác and Margaret Island are the coarsest ones, the dominant grain size of the Vác sample being 0,27 mm, that of Margaret Island 0,32 mm. Both samples contain, however, coarser fractions, *i. e.* those above, 0,5 mm. *(Fig. 2, A).* Another, but less important cause of the greater amount of garnet probably is the garnet contents of the andesites of the volcanic mountains.

Towards the southern reach of the Danube in Hungary, on can again demonstrate the admixture more metamorphic mineral. Along this reach the Danube is washing away, at many places, the Pannonian strata where metamorphic minerals are dominant, too [5, 12, 13, 19].

The *Sió,* discharching into the Danube, almost exclusively runs in a Pannonian loess territory, and it transports alluvia rich in metamorphic minerals into the Danube, too. It is especially from Dunaföldvár on that the amount of characteristically metamorphic minerals is increasing, *p. e.* that of the chlorite wich is as high as 16% at Baja. The increased percentage of chlorite may partly be attributed, here, to the fact that in relatively coarser fractions extracted from matters of finer grain size distribution, the amount of micas is always higher than in the finer fractions [14]. Bluish-green amphibole, a very characteristic mineral of the Danubian sediments here amounts to 11%, actinolite-tremolite to 2,8%, disthene to 2%.

It can be thus pointed out that the Danube transports alluvia of metamorphic origin, for the most part, in its reaches in Hungary; in the reach near the Austrian border the amount of calcite and dolomite is considerable, while from the Börzsöny-Dunazug Mountains downstreams the role of magmatic hypersthene and brown amphibole becomes important, too. [25, 26, 27, 28].

In the course of our examinations of heavy-mineral composition, carried out until now, we have found Danubian deposits, in Hungary, in the Great Hungarian Plain, namely between the Danube and the Tisza, where the eolian strata and the fluvial ones below them, to the depth of 500 or 600 metres, are of Danubian origin, and comprise the Quaternary and uppermost Pliocene (Levantine) deposits [16].

The *Rába,* right-hand tributary of the Danube, takes its source in the Eastern Alps, and it thus transports a dominant part of its alluvia from this region. Among the samples examined, coming from the Rába, those of Magyarlak and Rábapatona are coarse sand (0,5 to 2,0 mm) and even gravelly sands (12,0 to 20,0 mm), *i. e.* very coarse-grained, while the samples of Rum and Várkesző consist of medium-grained sand, for the most part (See *Fig. 2, B* and *Fig. 6, Graph II.*).

In the sediments of the Rába it is again the metamorphic character of the minerals which is dominant. In the Table as well as in the graph, monoclinic pyroxenes are to be seen in the column of magmatic minerals. As for their genesis, however, these minerals probably are diopsides of metamorphic origin, all over the catchment area of the Danube. Diopsides can be produced, however either by magmatic or by metamorphic processes, this is why we do not represent them separately. Monoclinic pyroxenes of the Danube Region differ in they lighter colours (except for the alluvia of the Ipoly) from the monoclinic pyroxenes of the catchment area of the Tisza, namely the latter are not diopsides, for the most part.

II.

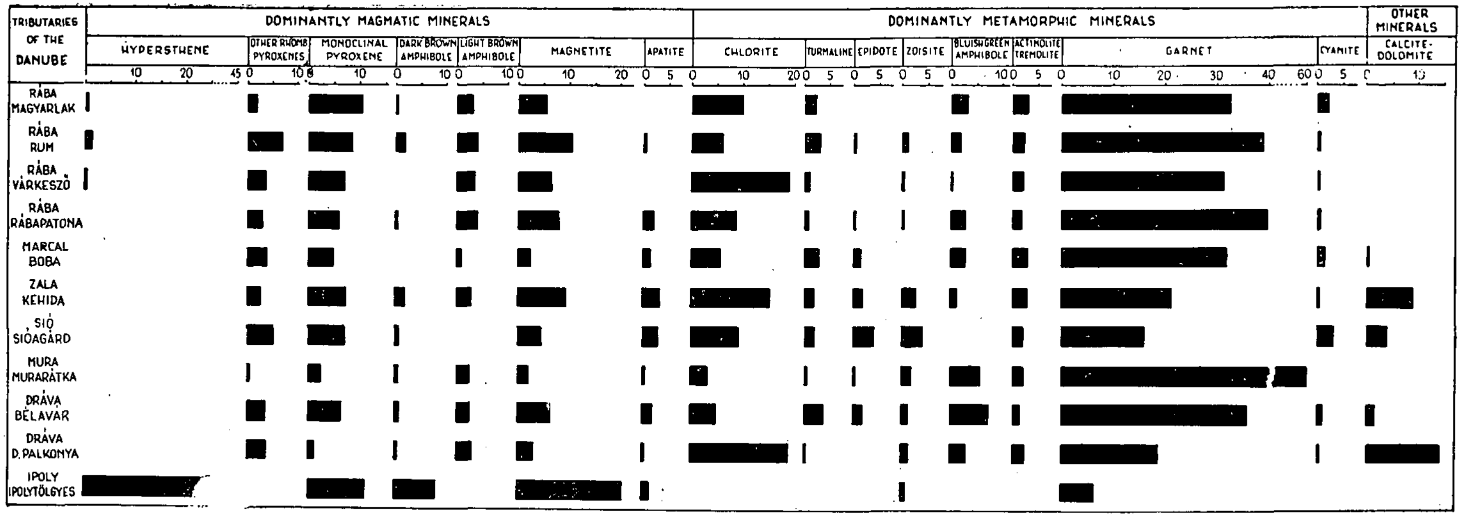


Fig. 6. (Digram II.) Dominant heavy mineral sorts in the alluvia of the tributaries of Danube.

Among magmatic minerals, it is the light-brown amphibole which plays a minor part in the Rába; as for the metamorphic ones, one finds considerable amounts chlorite, tourmaline, actinolite-tremolite and especially garnet, the latter representing more than 30% in each sample. Accordingly, the Rába transports, at all points, almost exclusively metamorphic minerals.

As regards the alluvia of the *Marcal*, discharging into the Rába, heavy-mineral examinations have already been carried out by G. BIDLÓ and E. TÖRÖK, it was only for the sake of completeness that we examined a medium-grained sand sample and found its composition analogous to those observed by previous examinations, with this difference that the amount of olivine was somewhat smaller, that of garnet being somewhat greater in the present sample [2]. In the alluvia of the Marcal the effect of the volcanic rocks of the environment (olivine) is demonstrable, too, nevertheless the alluvia of the Marcal are of metamorphic character, for the most part.

Heavy-mineral examinations of fine-grained sands of the *Zala* river at Kehida and of the *Sió* river at Sióagárd have shown that — as both rivers are running on dominantly Pannonian, loess terrain and the high metamorphic-mineral contents of the Pannonian sediments being known — no other river in Hungary transported alluvia so rich in metamorphic minerals that these two ones. *(Fig. 7,* A and *Fig. 6, Graph II).* In both of them, the part of metamorphic chlorite, tourmaline, epidote, zoisite, actinolite-tremolite, garnet and disthene is very important. The effect of the neighbouring Keszthely Mountains is shown, on the other hand, by the higher amount (8%) of dolomite and calcite in the Zala. [18, 22, 23, 24].

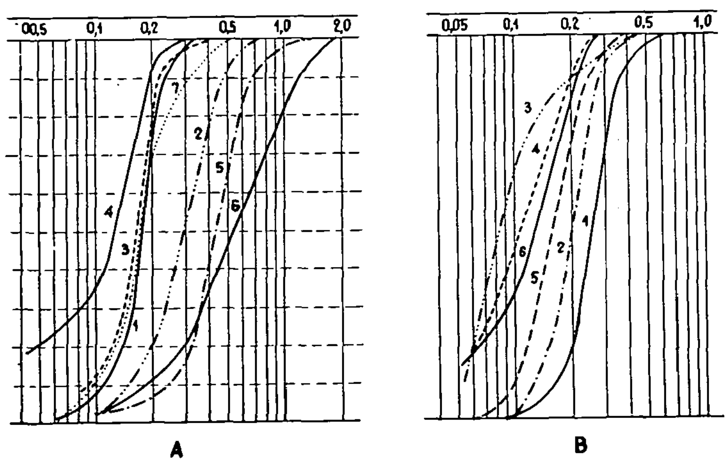


Fig. 7. **a**
Dráva
1. Bélavár
2. Drávapalkonya
Zala
3. Kehida
Sió
4. Sióagárd
Ipoly
5. Ipolytölgyes

b *Tisza*
1. Tiszakanyar
2. Tiszalök
3. Tiszaroff
4. Szolnok N.
5. Csongrád
6. Újszeged
Zagyva
6. Szentlőrinckáta
7. Jászberény

The *Dráva* and the *Mura* carry the dominant part of their respective alluvia from the Alps, too, therefore metamorphic character is again dominant in these sediments. The 0,1 to 0,2 mm fraction of medium-grained Mura sand contains 60% garnet. Such a high amount of garnet was not found in any other river of the country. Beside garnet, bluish-green amphibole (6%) and monoclinic pyroxene (6,6%) are important, too.

As for the composition of the Dráva sand at Bélavár and that of the medium-grained Dráva sand at Drávapalkonya, metamorphic character is still dominant. At Drávapalkonya the amount of calcite is as high as 14%; such a great amount indicates the effect of the Villány Mountains and, partly, that of the Mecsek Mountains (Fekete viz brook).

Fig. 8 shows the heavy minerals of the 0,1 to 0,125 mm fraction of the Drávapalkonya sand. Beside garnets, actinolite-tremolites and chlorites are well observable, too.

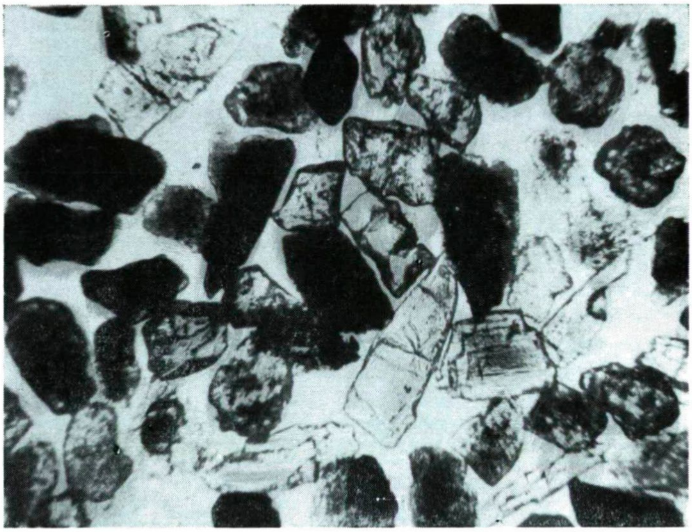


Fig. 8. Heavy minerals of the 0,1 to 0,125 mm fraction of Dráva sand, at Drávapalkonya.

The composition of the alluvia transported by the *Ipoly* are completely different from those of any other Hungarian tributary of the Danube. Minerals of magmatic character are dominant in the medium-grained sand of Ipolytölgyes. This difference is to be seen in *Fig. 6, Graph II.* and *Fig. 9. I. e.* hypersthene (see first column) did not appear in the above-mentioned tributaries of the Danube or it played there but a quite minor part, whereas it amounts to 42% at Ipolytölgyes. Dark-brown amphibole amounts to 8%, magnetite to 2%, biotite to 2%, while one very scarcely finds metamorphic and epigenetic minerals. This mineral association of particularly magmatic character comes from the Börzsöny Mountains.

Fig. 9 shows the heavy minerals of the 0,1 to 0,2 mm fraction of the Ipolytölgyes sample taken from the Ipoly. The amount of hypersthene, with quite idiomorphic crystals is dominant. Opaque inclusions of hypersthene are well observable, too. Beside hypersthene, one finds monoclinic pyroxenes and garnets.

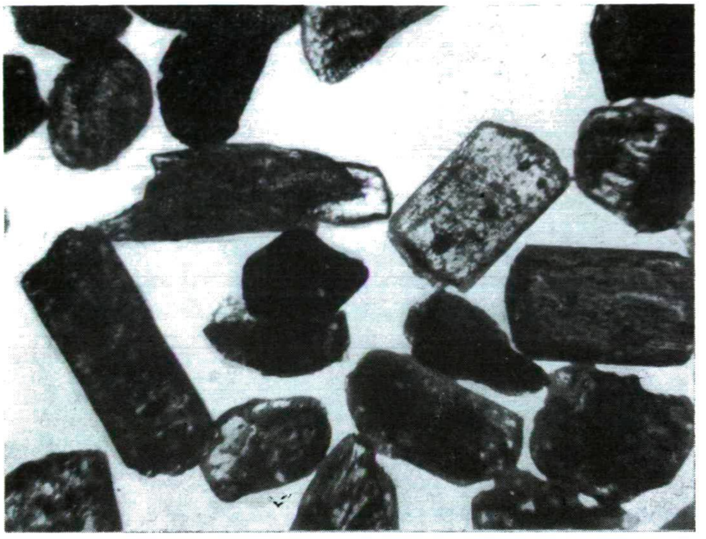


Fig. 9. Heavy minerals of the 0,1 to 0,2 mm fraction of Ipoly sand, at Ipolytölgyes.

Thus the dominant character of the alluvia of the Hungarian tributaries of the Danube — except for the Ipoly — is metamorphic. In this peculiarity, the sediments of the Danube Region differ from those of the Tisza Region (Tisza and its tributaries). The Ipoly, however, shows a composition completely analogous to the rivers of the Tisza Region.

The Danube and its Hungarian tributaries carry an important part of their alluvia from territories situated outside of the Carpathian Basin, *i. e.* from the Alps, while the alluvia of the rivers of the Tisza region come from the territory surrounded by the Carpathians. Inside the arch of the NE and E Carpathians, consisting of sandstones for the most part, there runs a Tertiary volcanic chain, thus the respective catchment areas are more different from each other as for their geology. Differences between the alluvia transported by the rivers will be more considerable, too, and they depend on the circumstance whether the rivers spring more or less near to the margins of the basins, or perhaps at the arch of the Carpathians.

THE TISZA REGION
(The Tisza and its tributaries)

As for the Tisza river, it can be pointed out that its tributaries produce important changes in the composition of the alluvia of the Tisza, therefore, in its course, the changes will be greater than in the case of the Danube. This feature is well illustrated *p. e.* by the changes in percentage of the hypersthene, plotted in the first column of the graph *(Fig. 10, Graph III)*.

The most remote medium-grained sand-sample examined comes from Tiszakanyár *(Fig. 7, B)*. As for its composition, one finds a characteristically magmatic heavy-mineral association, as well as in other samples taken from the Tisza. The amount of hypersthene is 23%, that of monoclinic pyroxene

III.

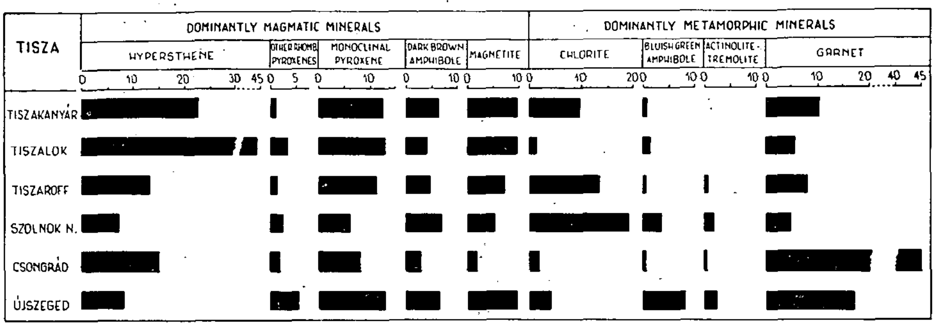


Fig. 10. (Diagram III.) Dominant heavy mineral sorts in the alluvia of the Tisza.

13%, dark-brown amphibole 6,5%, Minerals of metamorphic character play a less important part.

In the likewise medium-grained sand sample of Tiszalök, the role of hypersthene is even more considerable, it amounts to 44%. This higher amount of hypersthene, as compared to the previous samples, may be explained by the fact that the Hernád meanwhile joins the Tisza and the former carries considerable quantities of hypersthene. Other important minerals appear in similar amounts.

In *Fig. 11,* heavy minerals of the 0,1 to 0,2 mm fraction of the Tisza sand and Tiszalök can be seen. It is observable that the hypersthenes are still quite idiomorphic, here.

In the not quite well-sorted fine-grained sand sample of Tiszaroff as well as in that of Szolnok, the role of magmatic minerals is similarly dominant. It is observable that as far as Szolnok the amount of hypersthene decreases to 7%, probably because of increasing decay. The amount of micas is increasing, *i. e.* the 0,1 to 0,125 mm fraction represents a coarser part of the fine-grained sand, the part played by micas is always major in these fraction.

In the fine-grained and medium-grained sands of Csongrád, the amount of hypersthene and garnet is again greater. This change indicates the effect of the Zagyva and that of the Körös.

In *Fig. 12,* it is to be seen on the Tisza sand sampled at Csongrád that the hypersthenes are already rounded, which is an effect of a long transport. Beside hypersthenes, garnets are observable in major amounts.

In the fine-grained sand sample of Újszeged, it is the admixture of the alluvia of the Maros which is already demonstrable. There we find the above-mentioned minerals and, beside them, somewhat greater amounts of epidote, bluish-green amphibole and actinolite-tremolite.

On the basis of the above-mentioned data, the alluvia of the Tisza are well distinguishable from those of the Duna Region. The association of mag-

matic minerals of the Tisza is always characteristic, especially because of the higher amounts of hypersthene, dark-brown amphibole and dark-coloured monoclinic pyroxene (dominantly augit).

In the compositon of the tributaries of the Tisza, going from the W to the E — in the gravelly sand (terrace?) coming from Szentlőrinckáta and in the fine-grained sand of Jászberény, both taken from the *Zagyva* — it can be pointed out that the amount of garnet is very important, beside the general magmatic character of the Tisza Region *(Fig. 7, A* and *Fig. 13, Graph IV).*

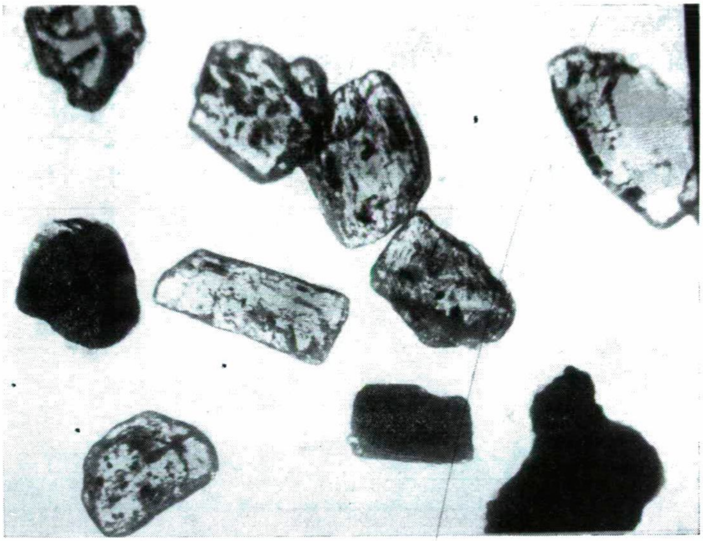


Fig. 11. Heavy minerals of the 0,1 to 0,2 mm fraction of Tisza sand, at Tiszalök.

Fig. 12. Heavy minerals of the 0,1 to 0,2 mm fraction of Tisza sand, at Csongrád.

IV.

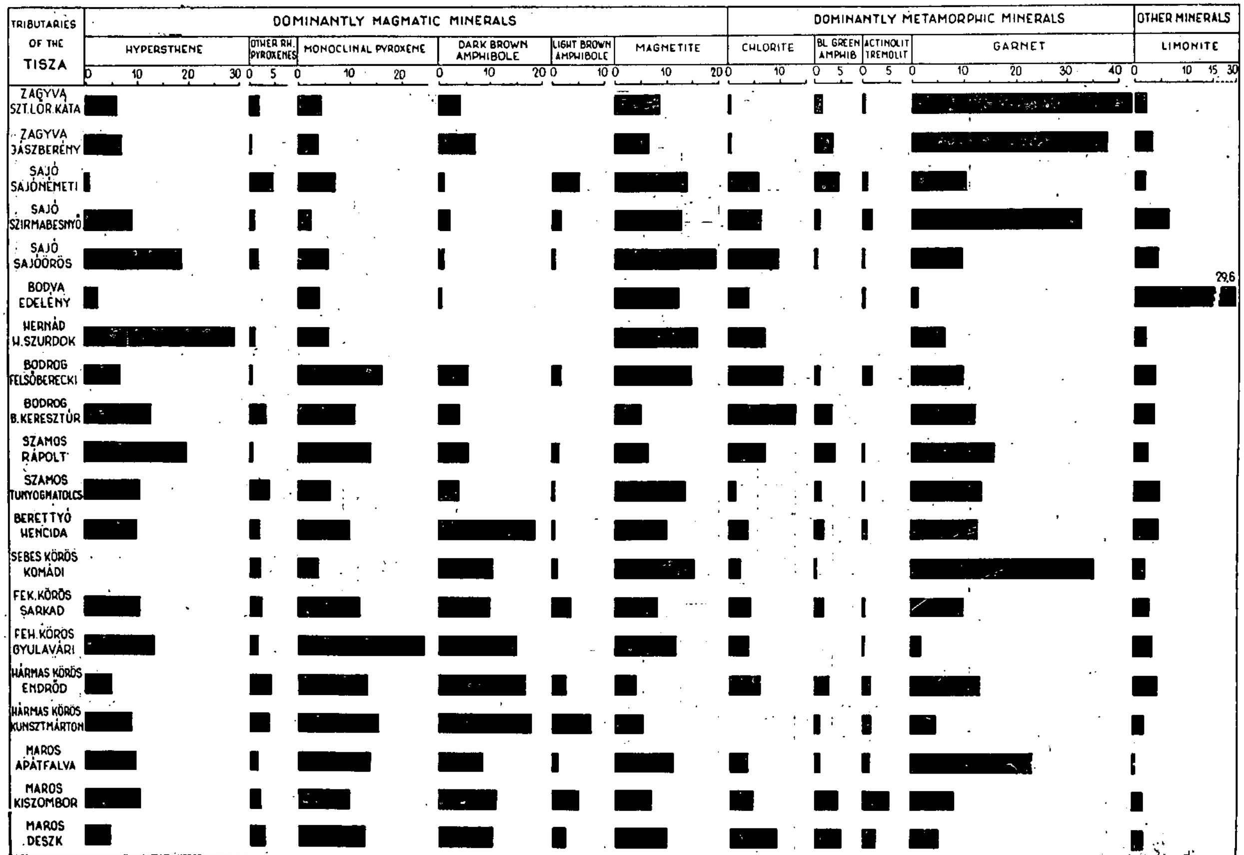
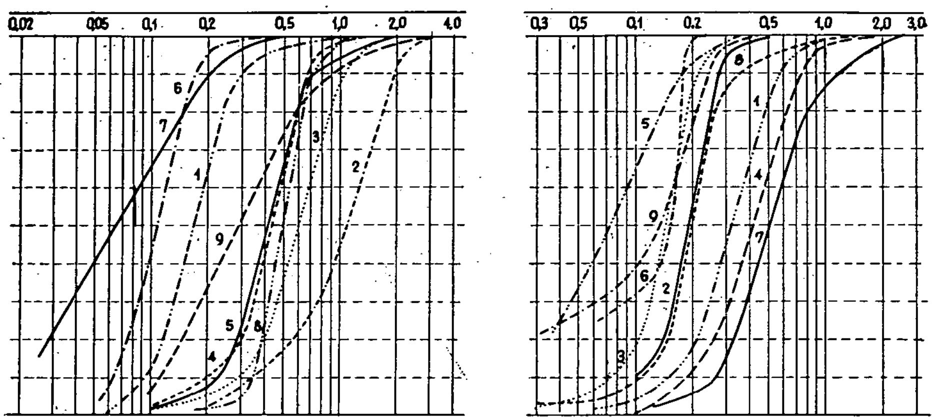


Fig. 13. (Diagram IV.) Dominant heavy mineral sorts in the alluvia of the tributaries of the Tisza.

In the 0,1 to 0,2 mm fraction, extracted from the coarser- and finer-grained sands, it amounts to 37 or 42%, too. The genesis of such a high amount of garnet will be pointed out by further investigations. It is quite probable, however, that it is transported from the Pannonian and Post-Pannonian strata, by the Zagyva and its tributaries. Between the Zagyva and the Tisza, in the environment of Pély and Kisköre, we have found sediments of similar character and heavy-mineral composition, as far as the previously determined lower boundary of the Pleistocene, *i. e.* to 200 m [4, 15, 22].

The *Sajó* and some of its tributaries take their sources in the Slovakian Ore Mountains, consisting of crystalline schists. This feature appears in the fine-grained sand sample coming from Sajónémeti, near the border *(Fig. 14, A)*. The amount of hypersthene and dark-brown amphibole is as low as 1%,



A B

Fig. 14. **a** *Sajó*
1. Sajónémeti
2. Szirmabesnyő
3. Sajóörös
Bodva
4. Edelény
Hernád
5. Hernádszurdok
Bodrog
6. Felsőberecki
7. Bodrogkeresztúr
Szamos
Rápolt
9. Tunyogmatolcs

b *Berettyó*
1. Hencida
Sebes Körös
2. Komádi
Fekete Körös
3. Sarkad
Fehér Körös
4. Gyulavári
Hármas Körös
5. Endrőd
6. Kunszentmárton
Maros
7. Apátfalva
8. Kiszombor
9. Deszk

while in the sample of Szirmabesenyő the amount of hypersthene increases to 9,4%, that of dark-brown amphibole to 2,3%, and before meeting the Tisza, at Sajóörs, the amount of hypersthene is as high as 19%. Thus the magmatic character becomes dominant after having taken up the rivers and brooks springing from eruptive terrains. The effect of carbonate-bearing mountains is demonstrable by the increase in calcite and dolomite.

The above-mentioned features are well illustrated in *Fig. 15* where the heavy-minerals of the 0,1 to 0,125 mm sand fraction coming from Sajónémeti are still metamorphic ones for the most part, and in *Fig. 16* where hypersthene becomes dominant in the 0,1 to 0,2 mm fraction of the sample of Sajóörs, situated at the mouth of the Sajó.

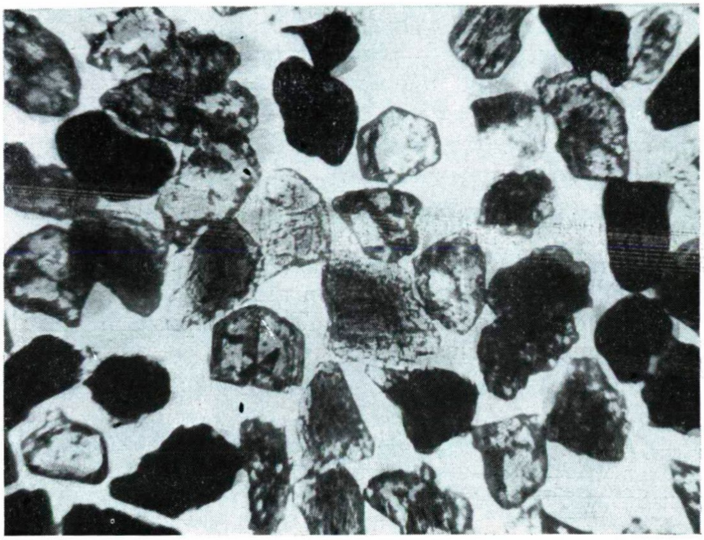


Fig. 15. Heavy minerals of the 0,1 to 0,125 mm fraction of Sajó sand, at Sajónémeti.

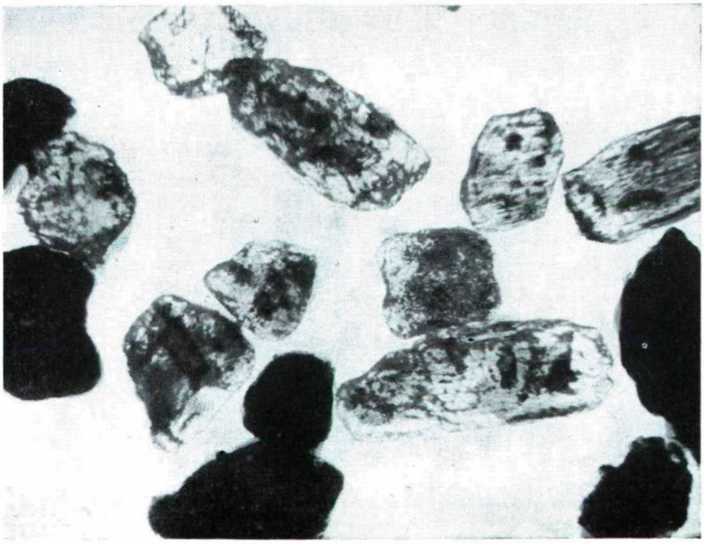


Fig. 16. Heavy minerals of the 0,1 to 0,2 mm fraction of Sajó sand, at Sajóörös.

In the medium-grained sand sample taken at Edelény from the *Bódva* flowing into the Sajó, the number of the occuring mineral species is small, because of the smallness of the catchment area. As for the minerals determining the genesis of the alluvia, one finds 4,6% glaucophane and 5,3% anhydrite. Glaucophane and anhydrite — transported by the Bódva — are demonstrable in small quantities in the Sajó, as far as Sajóörs, too. The limonite contents of alluvia of the Bódva are also very considerable, it amounts to 32%. It is probably upon the effect of this phenomenon and that of the surrounding territories, that the amount of limonite becomes higher in the Sajó, from the mouth of the Bódva downstreams.

The same can be seen in *Fig. 17, i. e.* in the middle of the figure one finds anhydrites of low refraction and, around them, weathered minerals and limonite grains.

The *Hernád,* likewise belonging to the catchment area of the Sajó transports in preponderant amounts hypersthene (29%), monoclinic pyroxene (6%) (dominantly augit) and magnetite (16%) in the 0,1 to 0,2 mm fraction of the medium-grained sand at Hernádszurdok. This composition already indicates the effect of the Zemplén Mountains.

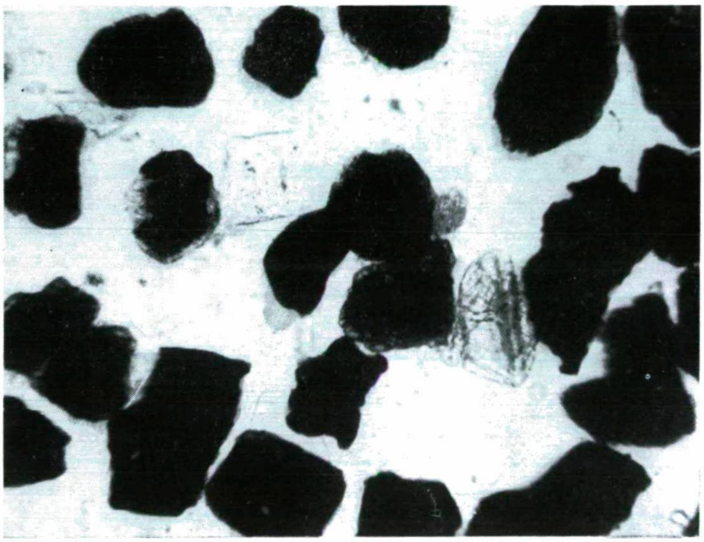


Fig. 17. Heavy minerals of the Bodva sand at Edelény, from the 0,1 to 0,2 mm fraction.

It is characteristic of the Sajó and its tributaries examined, that their weathered-mineral contents are quite considerable. They vary from 23 to 32%, with the exception of the very coarse sample of Szirmabesnyő.

In the alluvia of the *Bodrog,* the association of magmatic minerals is fairly rich, too, the percentage of magmatic minerals is even increasing from the border to the mouth of the river: at Felsőberecki, in the fine-grained sand, hypersthene amounts to 7%, monoclinic pyroxene to 16%, while at Bodrogkeresztúr, likewise in fine-grained sand, hypersthene already amounts to 23% and monoclinic pyroxene to 11%. It is thus evident that monoclinic pyroxene there plays an important part, too. The case of the other tributaries of the Tisza — to be treated hereafter — is analogous. On the Bodrog, in like manner as on the Hernád, it is the effect of the Zemplén Mountains which is demonstrable.

In the *Szamos,* namely in the medium-grained sand coming from Rápolt and in the medium- and coarse-grained sand taken at Tunyogmatolcs, the magmatic character was dominant, the hypersthene contents being also very considerable: it amounted to 10 or 20%. The role of monoclinic pyroxenes is important, too. The alluvia of the Szamos touching the Transylvanian Basin are somewhat richer in heavy-mineral species, this feature is due to the more varied geology of the area. [22].

In the Hernád, Bodrog and Szamos, the amount of hypersthene is always much higher than that of dark-brown amphibole. On the other hand, in the medium-grained sand sample taken at Hencida, from the *Berettyó,* it is to be seen that the amount of hypersthene is as high as 10%, *i. e.* greater than in the former. The graph also shows that the role of hypersthene and monoclinic pyroxene, dominantly augit, is important in the Hernád, Bodrog and Szamos, while the association of dark-brown amphibole, hypersthene and monoclinic pyroxene (dominantly augit) plays a more important part in the branches of the Körös and in the Maros.

In the sample taken at Komádi from the *Sebes Körös* no hypersthene was found, while dark-brown amphibole amounts to 10%. According to P. SZABÓ this sample should represent a Danubian alluvium. SZABÓ has considered the ratio of pyroxenes and amphiboles as the most important difference between the respective alluvia of the Tisza and Danube Regions. According to him, the dominance of pyroxenes represents Tisza sediments, that of ampiboles indicating Danubian ones. It is thus evident that dark-brown ampibole may be preponderant as compared to pyroxene, even in sediments of the Tisza Region. The alluvia of the Sebes Körös, however, can be distinguished from the Danubian sediments, as, in the former, the amount of tourmaline and epidote is higher, that of bluish-green amphibole hornblende being extremely low, while actinolite-tremolite and calcite-dolomite are completeley lacking. The Sebes Körös is also characterized by its considerable garnet contents amounting to 35% in the medium-grained sand.

In *Fig. 18,* garnets of the sand of the Sebes Körös are to be seen. The high-degree corrosion of these minerals is well observable.

In the sample taken from the *Fekete Körös,* at Sarkad, the amount of hypersthene exceeds that of dark-brown amphibole, but their ratio still remains almost identic. As compared to the Sebes Körös, the amount of garnet is lower; 10% in the samples we have examined. In the sample taken from the *Fehér Körös,* at Gyulavár, minerals and the occuring mineral species are similar to the former, as the geology of the respective catchment areas is almost identic.

In the samples taken from the *Hármas Körös* (Triple Körös = from the junction of the three branches), at Endrőd and Kunszentmárton, we find all the minerals that were demonstrable in its tributaries. The general feature, *i. e.* the predominance of dark-brown amphibole over hypersthene, remains. Monoclinic pyroxene occurs in a considerable amount, too.

As for the *Maros*, examinations of heavy-mineral composition have been carried out on samples taken at Apátfalva, Kiszombor, and Deszk; this order represents, at the same time, finer and finer sandy sediments. The Maros runs on a territory of varied geology, hence its alluvia are richer in mineral species.

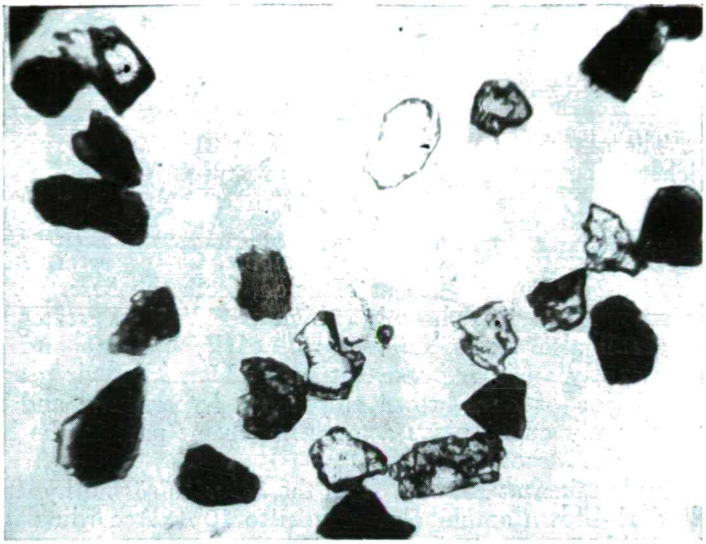


Fig. 18. Heavy minerals of the 0,1 to 0,125 mm fraction of Sebes Körös sand.

The role of hypersthene, monoclinic pyroxene (dominantly augit), dark-brown and light-brown amphiboles is quite important. Among the important metamorphic minerals, bluish-green amphibole, actinolite-tremolite are occuring in considerable amounts.

Fig. 19 shows also that dark-brown amphiboles, hypersthenes and garnets are to be seen beside each other.

On the basis of the examinations of heavy-mineral composition carried out so far, it can be pointed out that the alluvia of the Tisza from Csongrád down-streams, those of the Hármas Körös and Maros are not distinguishable from each other with absolute certainty. There occur the same minerals, in almost similar percentages, and minor differences observed in the course of the investigations are perhaps due to differences in grain-size distribution. Further, detailed investigations are still necessary in order to distinguish the above-mentioned sediments with certainty.

In the course of the examinations carried out so far, sediments of the Tisza-Region type have been found in the above mentioned surroundings of Pély and Kisköre to the depth of 200 m, and at Hajdunánás to 120 m, likewise to the lower limit of the Pleistocene. Along the intensely sinking Körös rivers, the same formations were found to the depth of 800 m already examined, at Makó to 170 m, at Szentes to 240 m, at Szeged to 175 m. At the two latter places, *i. e.* in the line of the Tisza, the sediments of the Tisza Region show a digitiform make-up, and they are wedging out between the sediments of the Danube Region [9, 11, 12, 13, 15, 16, 20, 21].

The above-described results of the examinations carried out on recent, fluvial, sandy sediments of known genesis reflect for the most part the lithology

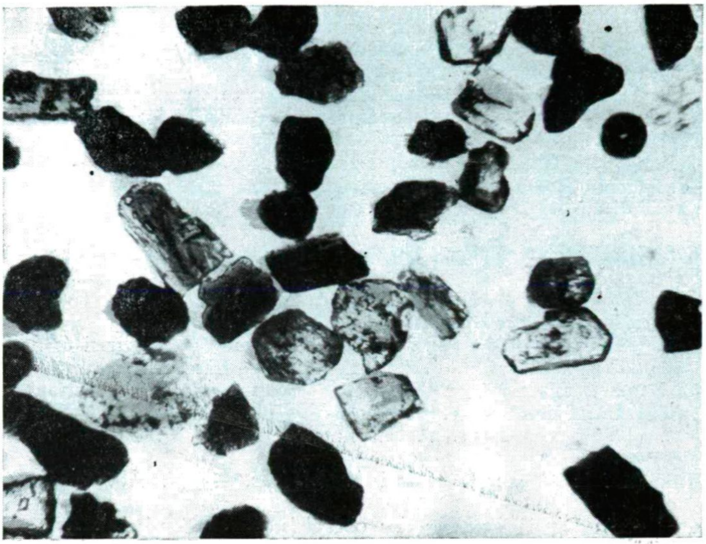


Fig. 19. Heavy minerals of the 0,1 to 0,125 mm fraction of Maros sand, at Deszk.

of the catchment areas of the respective rivers, thus the composition of a sand of unknown (fossil) origin may indicate the provenance of the same.

Further on, it is most desirable that similar examinations of alluvia should be carried out on every important river belonging to the centripetal river-system of the Carpathian Basin, besides the Hungarian rivers and reaches.

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